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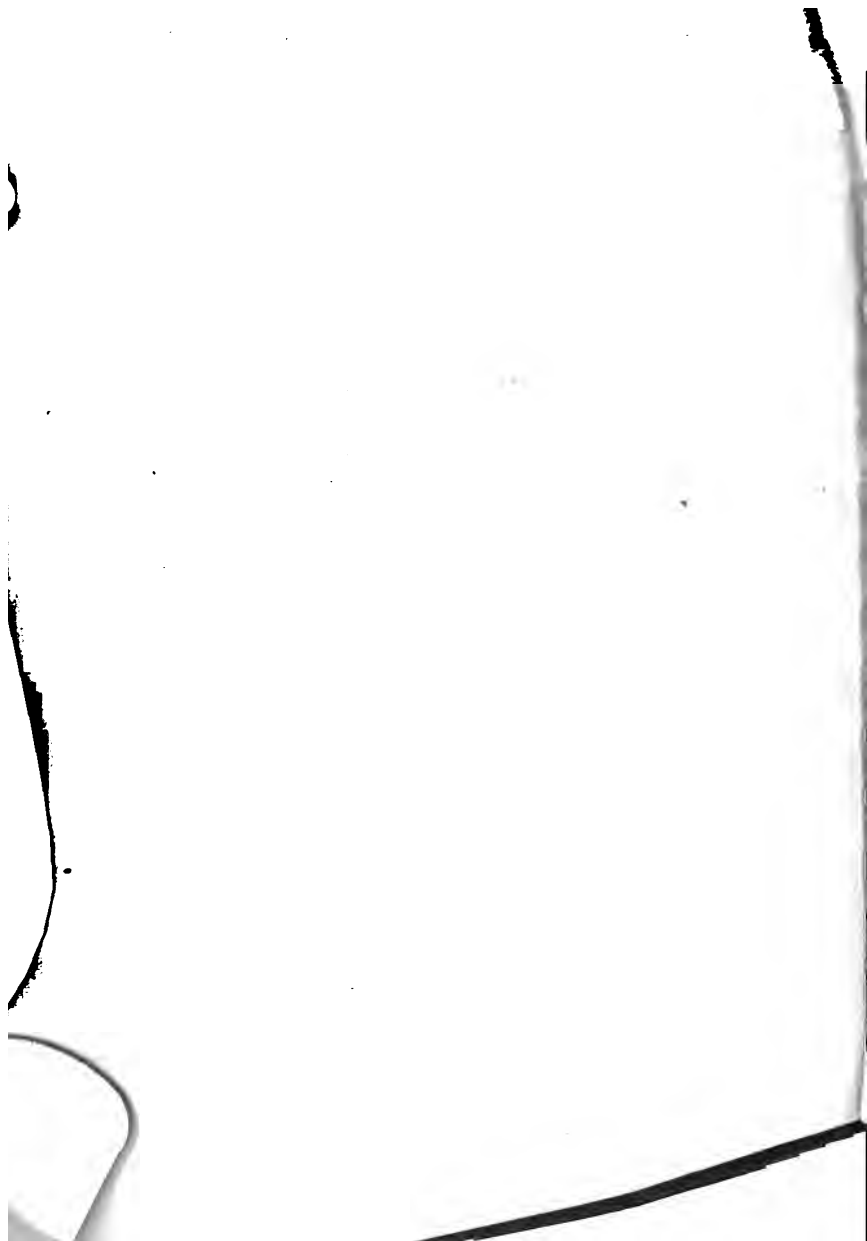
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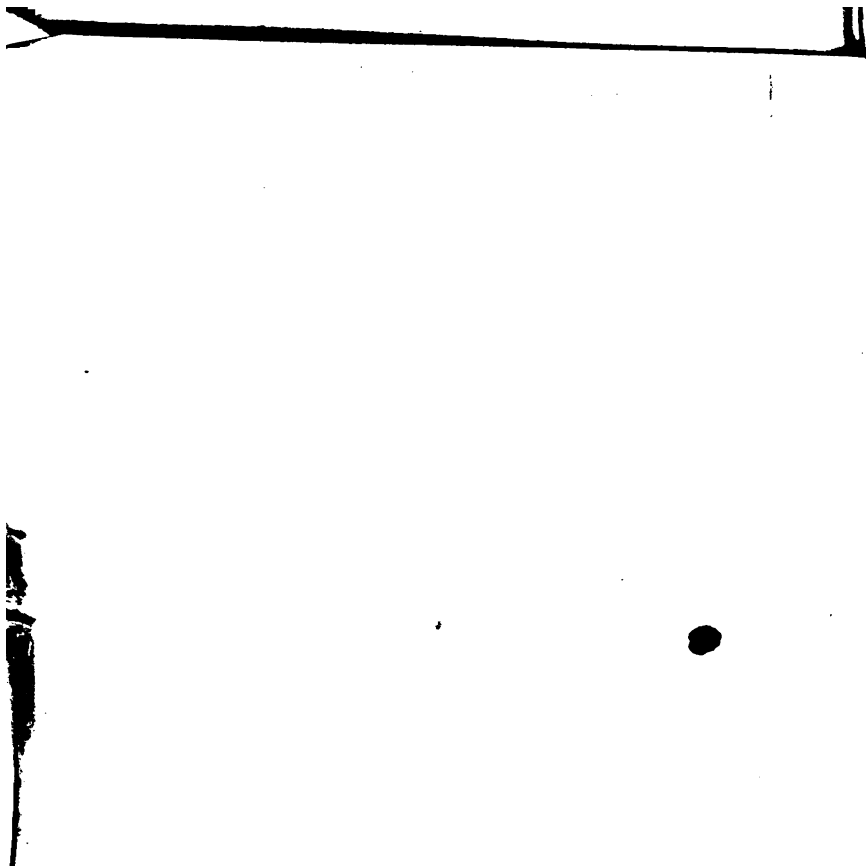
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THE BOSTON MACHINIST.

BEING A COMPLETE
SCHOOL FOR THE APPRENTICE
AS WELL AS THE
ADVANCED MACHINIST.

SHOWING HOW TO MAKE AND USE EVERY TOOL IN EVERY
BRANCH OF THE BUSINESS.

WITH A TREATISE ON
SCREW- AND GEAR-CUTTING
AND LESSONS TO AMATEUR INVENTORS, SHOWING THE
PROPER WAY TO INTRODUCE THEIR
INVENTIONS TO THE PUBLIC.

Illustrated with Over 40 Engravings of Tools of the Latest Design.

BY
WALTER S. FITZGERALD,
Inventor and Mechanical Engineer.

FOURTH EDITION, REVISED AND ENLARGED.
FIRST THOUSAND.

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PREFACE.

IN preparing this work the author has endeavored to give to the Mechanic a volume that he can readily understand, though he may not have a full knowledge of the scientific terms commonly used in works of this kind. He has also aimed to give a full explanation of every subject treated of in as few words as possible. He had thought of adding an article on the proper speed of turning and planing metals ; but as they vary so much in hardness, it is almost impossible to lay down any safe rule, and he has therefore concluded to omit it. He has also purposely omitted the subjects of Geometry and Machine Drawing, as they would have extended the volume beyond its proposed size ; and, besides, there are already published many good treatises on these subjects. Asking, therefore, that due allowance may be made for all omissions and imperfections, he submits his little work to the hands of those for whom it is intended.

Many of the engravings of tools shown in this work were kindly loaned to the author by the Pratt & Whitney Co. of Hartford, Conn., manufacturers of standard and special makes of tools and machinery.

WALTER S. FITZGERALD.

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THE BOSTON MACHINIST.

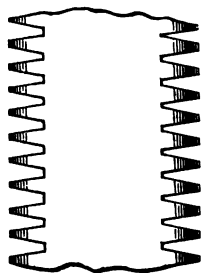
1. *The Apprentice's First Lesson.*

THE first thing for the apprentice to learn is to clean and keep in order the lathes, planers, drills, milling- and slabbing-machines. This is done by brushing off the chips, and then wiping them with a wad of cotton waste. To clean a lathe run the carriage and puppet-head about four feet from the main head; then to keep the feed and gears clean brush all the chips towards the carriage, and after doing this wipe the head and ways clean and oil them. Then, after cleaning the carriage and puppet-head, run them back to the main head, brush the chips from the lower end of the lathe, wipe and oil the ways, and it is done.

2. *Lesson Second.*

The next lesson is to learn to trim castings. This is done by chipping off the rough places with a cold chisel and then filing them smooth with a

Side view of a Fluted Reamer.



Section of a Mongrel Thread Screw for great wear.

second-hand file, which answers quite as well as a new one.

3. *Lesson Third.*

The next thing to learn is to centre bolts, shafts, etc. To do this take a centre-punch and hammer, and punch it into the centre of each end of the shaft or bolt as near the centre as you can guess; then find a pair of bench-centres and spring them apart, putting the points into the punch-marks you have made in each end of the shaft. After doing this take a piece of chalk in one hand and turn the shaft with the other, holding the chalk near enough to the shaft, near the ends, to touch the side that runs out. When you have done this, take the shaft from the centres and remove the punch-mark towards the side marked by the chalk. Continue these operations till the shaft is true at the ends.

4. *Lesson Fourth.*

Having learned to centre a shaft, you will now proceed and learn to drill the centres. In doing this use a drill about one sixteenth of an inch in diameter. Put the drill into a hand-lathe, and with one end of the shaft upon the centre drill the other, continually turning it around while drilling. They should be drilled about one fourth of an inch

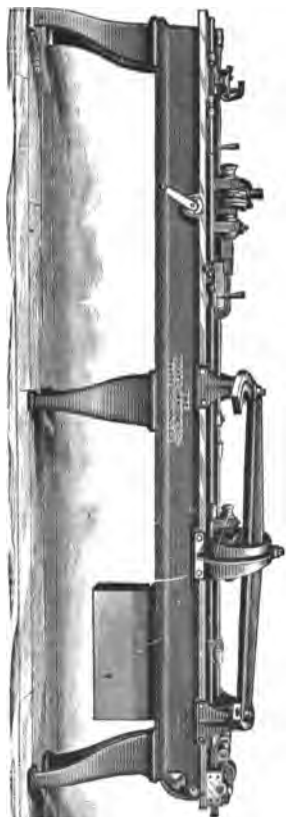
deep. After doing this countersink them with a three-square countersink, made for the purpose.

5. *Lesson Fifth.*

You will now learn other modes of drilling, the first being to drill holes through pieces of iron. In doing this they are first laid out a certain distance from the edges with a pair of dividers. Then make a punch-mark the distance from the edge or position where you wish to drill the hole. After marking this punch-mark set your dividers the size you want to drill the hole, and strike a circle around the mark made by the punch. Having done this, proceed to drill the hole, taking great care to drill within the circle, and if your drill runs to one side chip a piece out of the opposite side with a half-round chisel; this will bring the drill back to the centre of the circle. Continue this practice till the hole is perfectly true, and if you are careful at the first you will find no difficulty in drilling holes, and drilling them properly.

6. *To Drill a Large Hole in the End of a Shaft.*

This is only done when you have no chuck that will hold the shaft. To do it properly drill a small hole the depth required with a straight spiral drill, or if you have none use a flat drill that is straight



Rifling Machine.

on the sides; then follow with one or two more larger sizes, as may be required. The object of using a small drill first is because, there being less pressure endwise on the drill, it will not run out sideways, as it would if the small holes were not drilled first. In drilling with small drills, such as centre-drills, always speed up your drill as fast as it will run. This prevents breaking the drills, and there is no danger of burning the points thereof, as some suppose, except the steel be very hard.

7. *To Straighten Shafting.*

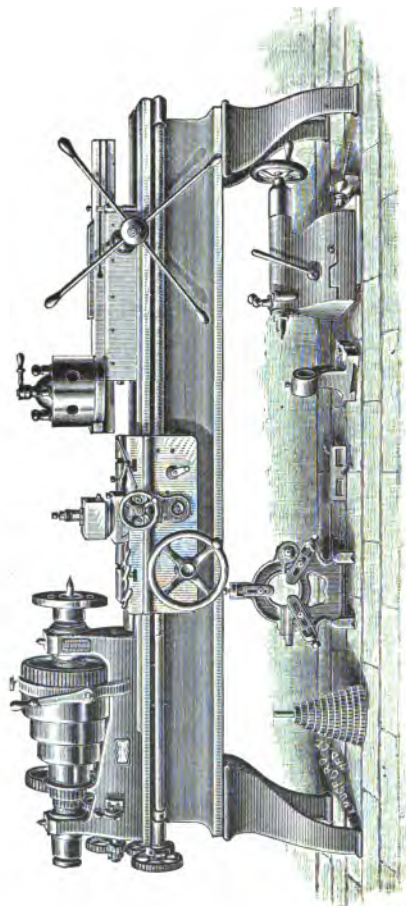
This should be done by centering, as before explained; then put into a lathe, and the ends squared up with what is called a side-tool. After doing this take a piece of chalk and try it in several places to find out where the worst crooks are; then, if you have not a machine for springing shafting, spring it with a lever where the worst crook is, and continue this operation till the shaft is straight.

While springing a heavy shaft with a lever the tool-block on the carriage is used as a fulcrum while springing it, and at each end of a crook, a link having its ends twisted to a right angle is placed over the shaft, and these links extend down enough below the bed of the lathe to allow a bar to be run through them, these bars being sup-

ported by the lower sides of the bed. A helper is required while doing this work. When the shaft is a small one, it may be straightened on an anvil or other heavy body of metal with a sledge or a hammer; and it is well when trying to find the crooked places in a shaft to use a tool having a square end placed against it in order to find the largest crooks, and also to see how far it is from being true. A shaft that is nearly true may be sprung while on the centres, using the tool-block as a fulcrum for the lever, and without the use of links.

8. *Setting a Lathe Straight to Turn Shafting.*

First see if your centres are true; if not, turn them up. For this purpose a square-end tool is best; and they should always be kept true to a three-square gauge. Unless you do this, you will spoil about half your work, as many a one *has* done. After this is done set your puppet-head so that it will turn the shaft straight, and if it has no straight mark upon it turn one end of the shaft for about an inch; then, without moving your tool, take the shaft out of the lathe. Then run the carriage down to the main head, put your shaft into the lathe again, with the end that is turned towards the main head, and if the tool touches the



Engine lathe with turret head. (Pratt & Whitney Co.)

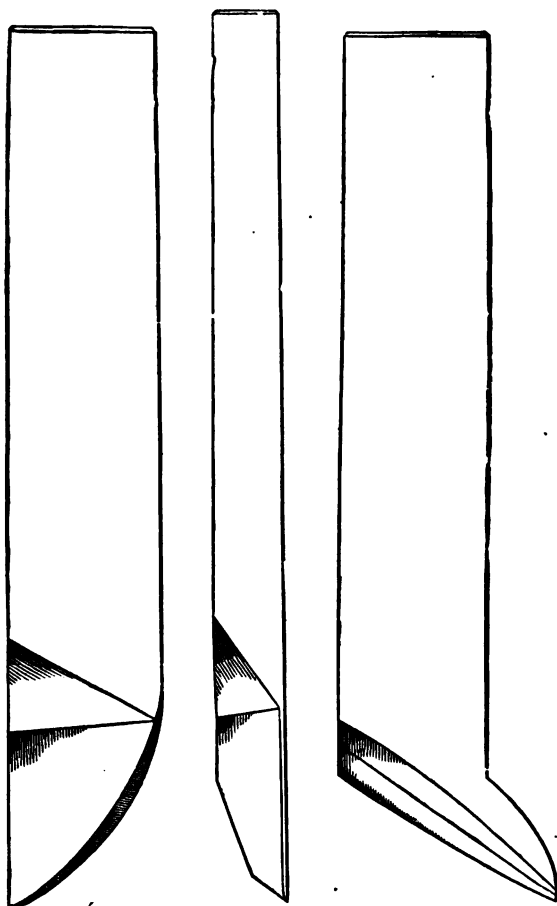
place you have turned the lathe is straight. If it does not touch, screw over the puppet-head, and keep trying it until your tool touches the place turned, while on either centre of the lathe.

9. *Turning Shafting.*

To do this properly two chips should always be run over the shaft, for the reason that it saves filing and leaves the shaft truer and more round ; and on shafts thus turned the time saved in filing more than compensates for the time lost in turning. Before you commence you will put your feed-belts or gear on a coarse feed. Turn it a sixty-fourth of an inch larger than the size required. Having turned off this chip, commence the finishing-chip, and turn it small enough to have the pulley-wring on about an eighth of an inch without filing. This will leave it large enough to file and finish. If there are couplings to go on a shaft, with holes smaller than the holes in the pulleys, the ends of the shaft, where they fit on, should be turned down to within a sixty-fourth of an inch of the size desired before any part of the shaft is finished ; that is, *every* part of a shaft should be turned to within a sixty-fourth of an inch of the size required before *any* part of it has the finish-chip taken off. The reason for this is that it leaves

every part of the shaft perfectly true, which would not be the case were it done otherwise. Having done this, you will file the shaft so that the pulleys will slide on, and the couplings so that they will drive on, polish the shaft with a pair of polishing-clamps and some emery, and it is done.

In turning a long shaft a fixture known as a cat-head is sometimes used to steady it while being turned. This fixture is a block of round cast iron about six inches long, and has a hole through it about an inch larger than the shaft, or about three inches in diameter, and at each of its ends are three set-screws. This fixture is placed on the shaft about equidistant from its ends, and the screws are set against the shaft and moved until the outside is perfectly true at both of its ends while the shaft is on the centres of the lathe. This fixture is then placed within the slides of a steadying-rest that is bolted to the ways, and these slides are then screwed inward until they touch the fixture on either side; then the screws on the side of these slides are screwed up to hold them in position and prevent the shaft from trembling while being turned. In long slender shafts a rest may be used to follow the tool. This rest is bolted to the carriage, and prevents the shaft from springing away from the tool while it is being turned.



A Left-hand Side-tool, side view.
A Right-hand Side-tool, top view.
A Round-ended Tool, for facing cast iron, etc.

10. *Setting a Lathe to Turn Tapering.*

This is done by calculating the taper, a certain amount to the foot or length of the piece to be turned. Therefore, if you have a shaft to turn a foot long, with one end one inch larger than the other, you will set your puppet-head over one half inch, and you will get the required taper of one inch to the foot. If you have a shaft a foot long, and wish to turn one half of it tapering half an inch, you will set the puppet-head over half an inch, as before; for the shafts being a foot long, you must calculate your taper from the length of the shaft; and if the taper is to be half an inch larger at six inches from the end, and the shaft exactly a foot long, the taper would be, as before, one inch to the foot. If you have a shaft to turn that is twenty inches long, and you wish to turn it tapering two inches in its whole length, set your lathe over one inch, and this will give you the taper required—two inches in twenty. If you have a shaft twenty inches long, and you wish to turn a taper half an inch in five, set your puppet-head over one inch, as before; this will give you a taper of five inches in twenty, and half an inch in five; because half an inch is one fourth of two inches, and five inches is one fourth of twenty. If you

have a shaft twenty inches long, and want to turn it taper one inch in ten, set your lathe over one inch, as before, and you have it ; for the shaft being twenty inches long and two inches taper in its *whole* length, it would be one inch only in half its length.

11. *Tools for Different Kinds of Turning.*

1. The best tool for squaring up the end of a shaft is what is called by machinists a side-tool, and the best tool for turning small shafting is a tool known as a diamond point.

2. The best tool to turn heavy shafting is a round-end tool, made to stand high like a diamond-point, and to cut freely from the side.

3. The best tool to turn a balance-wheel of cast iron, or to square up any large surface, is also a round-end tool, made well tapering to cut from the side.

4. The best tool to cut off a shaft with is a tool made thin and having the end stand no higher than the centres of the lathe, instead of up, as in turning-tools ; this prevents their running in and breaking.

5. The best tool to bore out a hole is a lathe-boring tool with the end turned on a right angle to the left and the point turned up hooking. These tools bore far nicer than those made square on the top.

6. The best tool with which to cut a V-thread screw is a V-thread tool with the points ground to lean down when finishing, as it prevents running inward and breaking the tool or tearing the screw.

7. In cutting a square thread first use a square-end tool about three fourths of the thickness of the thread you design to cut, and finish with one the size of the thread. The same rule applies when cutting a thread within a hole.

12. *Planer Tools.*

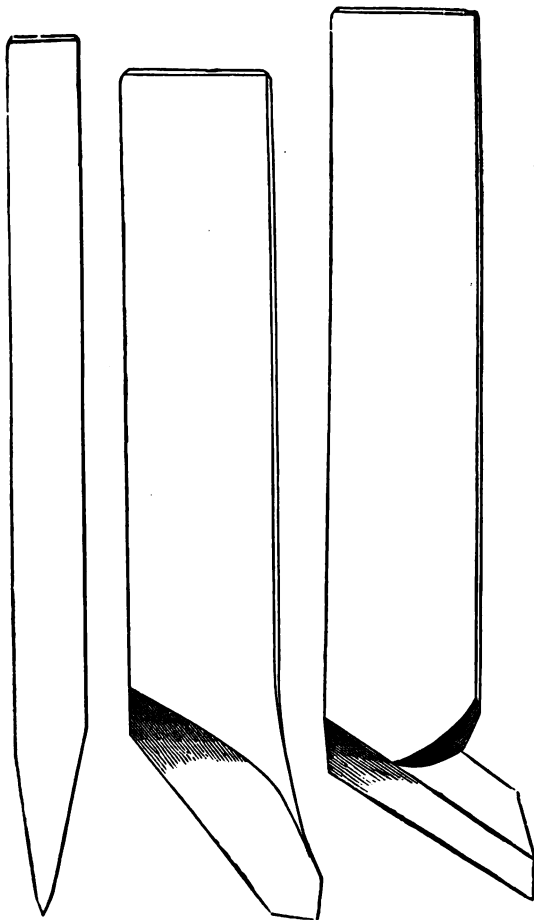
The best tool for ordinary planing is a half-side tool made short, and with the point turned upward as an ordinary diamond-point.

The best tool for squaring up a cast iron surface is a round-end tool, made to cut from the side.

The best tools for planing under, as in slide-rests, etc., etc., are sharpened up to a point, with the point turned upward, and with a taper from the point to the body of about two inches.

13. *Chucking Pulleys.*

The term chuck means to secure a piece of work in a certain position so as to drill or plane it true. The same name is given to the instrument employed in holding pieces of round metal, wheels, pulleys, etc. There are many kinds of these chucks :



Top View of a Screw-tool for cutting V Threads.
Side View of a Tool for cutting V Threads.
A Diamond-point Tool, for turning Small Shafting.

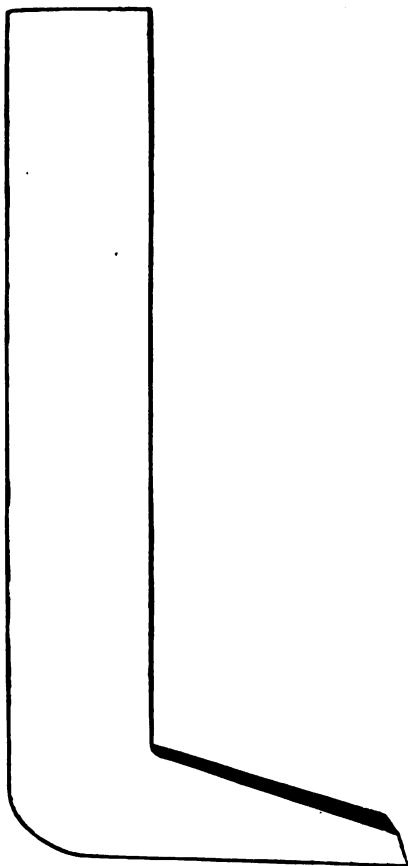


A Tool for cutting off a Shaft; is also used for cutting Square Thread-screws.

A Lathe Tool for boring Holes.

A Tool for cutting a Screw inside a hole.

one is a large and round piece of metal having a hole cut in one side of it and within which is cut a screw for the purpose of securing it to the spindle of a lathe. On the side opposite is a certain number of jaws, usually three or four, which screw together for the purpose of holding a wheel, or other piece of work, while it is being drilled. In chucking a wheel or pulley the first thing to be done is to screw it into the jaws of the chuck, as near the position desired as you can guess. After doing this screw a tool into the post, and set one end of it near the face of the pulley, then turn and adjust the wheel by means of the screws until the tool touches it all around. After doing this true the edges in the same way ; and then try the face again to see if it has moved. Some wheels are cast oblong by the pattern's shrinking ; and when wheels come this way the proper mode of chucking them is to set your tool against the face, as before, turn and adjust the wheel so that it will touch the tool at two opposite points, then with a rule measure the two points farthest from the tool, and adjust them so they will be equal, and the wheel will be true. Some mechanics use a piece of chalk, but this is an improper way to true a wheel, even when it is perfectly round, for a wheel that is not chucked and drilled true costs more time in turning than is



A Tool for planing a Key-way through a Hole.

needed to chuck and drill half a dozen wheels and pulleys that are perfectly drilled and for patterns they should be trued by the inside of the face and on the sides by the arms.

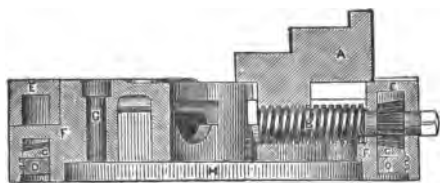
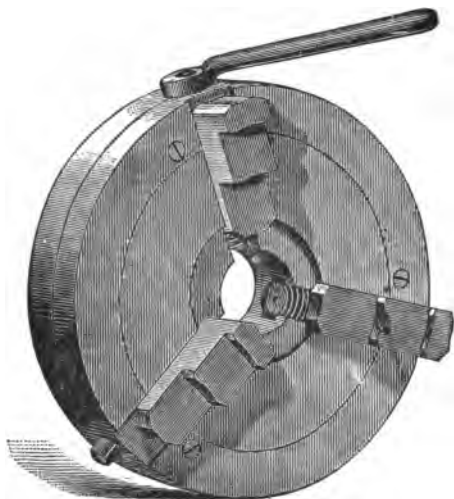
Combination Lathe-chuck.

CONCENTRIC OR ECCENTRIC, UNIVERSAL OR INDEPENDENT.
JAWS REVERSIBLE.

This chuck has been improved from time to time, and is so well known that but a brief description is necessary. The jaws slide in radial slots, and at all times these slots are covered, excluding dirt and chips.

The chuck is rendered universal or independent at will by the meshing or unmeshing of the circular rack with the bevel-pinion on the screw. This is quickly done by pressing the thumb-catch on the back of the chuck and revolving the supporting ring.

In holding eccentrics or irregular work the jaws may be placed in any desired position and the rack and screw-pinions meshed, forming a chuck with eccentrically placed but with simultaneously moving jaws. The jaws *in all sizes except the 4- and 6-inch are reversible*, and the whole chuck may be dismembered for cleaning or oiling while on the lathe-spindle by simply removing three screws, a desirable feature in large chucks.



Combination Lathe-chuck. (Pratt & Whitney Co.)

14. *Setting the Chuck-rest.*

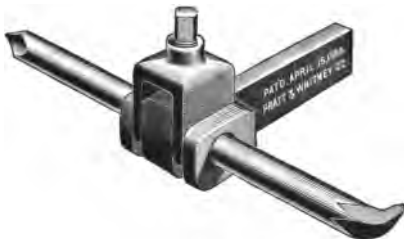
In doing this set it into the tool-post with the middles of the slats through which the drill passes exactly as high as the centres of your lathe, for if it is above or below the centres it will cut the hole larger than the drill, and thereby spoil the wheel. Having set the rest, you can proceed to drill the wheel. This should be done with two drills, and where the holes are cored badly out of true even three should be used, if you would have the hole perfectly true and the last drill should only cut a chip one sixteenth of an inch. This leaves a good and true hole.

15. *To Drill a Hole Where You have No Reamer.*

It is sometimes necessary to drill a hole of an exact size to fit a certain shaft, and at the same time have it smooth without reaming it. This may be done by first drilling a hole one hundredth of an inch smaller than the size desired, and then making a drill the exact size and running it through to finish with. This last drill should have the corners of its lips rounded, like a reamer, and the hole should be finished without holding the drill with a rest.

16. *Boring a Hole with a Boring-tool.*

In boring a hole with a boring-tool it is usually necessary to drill the hole first, and too much care cannot be taken in finishing. An iron gauge should be made first; it is usually made of a piece of sheet iron or wire. The hole should then be drilled



A Boring and Inside Threading Tool. (New Invention.)

smaller than the size desired, and then bored to the required size, and it is impossible to bore a hole perfect without taking two or three light chips, mere scrapings, with which to finish. Holes may in this way be bored as nicely as they can be reamed.

17. *Squaring or Facing Up Cast-iron Surfaces.*

A round-end tool is best for this. A rough chip should first be taken off over the entire surface to be faced. Then speed your lathe up and, taking a light chip, merely enough to take out the first tool-

marks, run over the entire surface again. In turning up surfaces it is always best to begin at the centre and feed out, as the tool cuts more free and will wear twice as long.

18. *Scraping Cast Iron Smooth.*

To scrape cast iron it is necessary to put a rest close to the surface to be scraped, and then with a thin wide scraper commence by resting your scraper on one edge and scraping, twisting the scraper, and sustaining it while cutting, in your hand. You must not bear on hard, but scrape as light a chip as possible, and you will have no trouble in scraping cast iron.

19. *Keep Your Lathe Clean.*

I again remind you of keeping your lathe clean, and your centres in shape, as, unless you do this, you will soon spoil every arbor in the shop; and the ways of your lathe will be torn away, so as to be unfit to have any nice piece of work done upon them.

20. *Boring Holes with Boring-arbor.*

A boring-arbor is a shaft with a steel tool set in it for the purpose of boring holes of great length, and is designed to be used in a lathe. In doing

this properly you must first see if your lathe is set straight. If not, adjust it. Having done this, put the piece of work to be bored in the carriage of your lathe, pass your arbor through the hole to be bored, and put it on the centres of your lathe. Having done this, adjust your work true to the position desired by measuring from the point of the tool, continually turning round the arbor from side to side of the piece to be bored while you are bolting it to the carriage, and measure until it is perfectly true. Having done this, bore the hole, and take for the last chip only a hundredth of an inch. This makes a true and smooth hole. It is impossible to make a hole true with any kind of a tool when you are cutting a large chip, for the tool springs so that no dependence can be placed upon it.

21. *To Make a Boring-Tool that will Not Chatter.*

Boring-tools, when used in small arbors, are always liable to chatter and make a rough hole. To prevent this the tool should be turned in a lathe, while in its position in the arbor, upon the circle of the size of the hole to be bored, and the bearing lengthwise of the tool should be only as wide as the feed of the lathe, for if the bearing of the tool is on the whole face it will chatter.

22. *Gearing a Lathe for Screw-cutting.*

Every screw-cutting lathe contains a long screw called the lead-screw, which feeds the carriage of the lathe. While cutting screws upon the end of this screw is placed a gear, to which is transmitted motion from another gear, placed on the end of the spindle. These gears each contain a different number of teeth, for the purpose of cutting different threads, and the threads are cut a certain number to the inch, varying from one to fifty. Therefore to find the proper gears to cut a certain number of threads to the inch you will first multiply the number of threads you desire to cut to the inch by any small number, four, for instance, and this will give you the proper gear to put on the lead-screw. Then with the same number, four, multiply the number of threads to the inch in the lead-screw, and this will give you the proper gear to put on the spindle. For example, if you want to cut twelve to the inch, multiply twelve by four, and it will give you forty-eight. Put this gear on the lead-screw. Then with the same number, four, multiply the number of threads to the inch in the lead-screw. If it is five, for instance, it will give you twenty. Put this on the spindle, and your lathe is geared. If the lead-screw is four, five, six, seven, or eight,

the same rule holds good. Always multiply the number of threads to be cut first. Some, indeed most, small lathes are now made with a stud geared into the spindle, which stud only runs half as fast as the spindle, and in finding the gears for these lathes you will first multiply the number of threads to be cut, as before, and then multiply the number of threads on the lead-screw, as double the number it is. For instance, if you want to cut ten to the inch, multiply by four, and you get forty. Put this on the lead-screw. Then, if your lead-screw is five to the inch, you will call it ten, and multiply by four, and it will give you forty. Again put this on your stud, and your lathe is geared ready to commence cutting.

23. *Cutting a Screw in an Engine-lathe.*

In cutting V-thread screw it is only necessary for you to practise operating the shipper and slide-screw handle of your lathe before cutting. After having done this until you get the motions you may set the point of the tool as high as the centre, and if you keep the tool sharp you will find no difficulty in cutting screws. You must, however, cut very light chips, mere scrapings, in finishing, and must take the screw out of the lathe often, and look at it from both sides, very carefully, to see

that the threads, do not lean, like fish-scales. After cutting polish with an emery-stick and some emery.

24. *Cutting Square-thread Screws.*

In cutting square-thread screws it is always necessary to get the depth required with a tool somewhat thinner than one half the pitch of the thread. After doing this use another tool exactly one half the pitch of the thread, and use it to



A Tool for Square Threads with Stock or Tool-holder.

finish with, cutting a light chip on each side of the groove. After doing this polish with a pine-stick and some emery. Square threads for strength should be cut one half the depth of their pitch, while square threads for wear may and should be cut one half deeper than the pitch.

25. *Mongrel Threads.*

Mongrel, or half-V, half-square threads are usually made for great wear, and should be cut

one fourth deeper than their pitch, and for extraordinary wear they may even be cut once and one half the depth of their pitch. The point and bottom of the grooves should be in width one fourth the depth of their pitch. What is meant here by the *point* of the thread is the outside surface. And the bottom of the groove is the groove between the threads. In cutting these threads it is necessary to use a tool about the shape of the thread, and in thickness about one fifth less than the thread is when finished. As it is impossible to cut the whole surface at once, you will cut in depth about one sixteenth at a time, then a chip off the sides of the thread, and continue in this way, alternately, till you have arrived at the depth required. Make a gauge of the size required between the threads, and finish by scraping with water. It is usually best to leave such screws as these a little large until after they are cut, and then turn off a light chip to size them. This leaves them true and nice.

Since a long screw while being cut for either a square or a mongrel thread will spring or bend, it should be left a fortieth of an inch above size until the thread is cut. Then a chip should be taken from the outside with a sharp tool, using oil in cutting it, thus leaving it much smoother than if it were cut without the oil.

26. *Planing Metals.*

The first operation in planing is to oil your planer and find out if the bed is smooth. If it is not, file off the rough places. Then change the dogs to see if they work well, and find out the movements of the planer. After doing this bolt your work on to the bed, and if it is a long thin piece plane off a chip; then turn it over and finish the other side, taking too chips, the last of which should be very light. Great care should be taken in bolting it to the bed not to spring it. After finishing this side turn it to the other side, and take off a light cut to finish it.

27. *Planing Perpendicularly.*

In planing perpendicularly it is necessary to swivel the bottom of the small head around, so it will stand about three fourths of an inch inside of square, towards the piece you are to plane. This prevents breaking the tool when the bed runs back.

28. *Planing a Key-way.*

To place a key-way in a shaft it is necessary to first drill a hole, the size you intend to make the key-way, as deep as you want to plane. Then with a square-end tool plane the key-way a little

narrower than you design to finish it down to the proper depth. After doing this finish with a tool of the desired size. Some think it unnecessary to use two tools to plane a key-way, and argue that it takes more time. This may be the case, but it is impossible to plane a key-way with one tool, especially a narrow one, without tearing it, and again it is impossible to tell whether or not the tool will run under sidewise until you have planed the way its depth. Therefore, if you first plane the way with a narrow tool, and it is found to run under, it is very easy to set it right in cutting out the finished chip. In setting a tool to cut a key-way set a square on the planer-bed, and try both sides of it near the point to see that it is perpendicular. This will usually prevent its running under.

Having set both sides of this tool to correspond with the edge of a square, move the bed of the planer to a point above and near to the shaft where the key-way is to be planed. Then with the beam of a square on the bed of the planer, and the edge of the blade in the square against the shaft and opposite the tool, measure the distance from the square to the tool on each side, and move the tool until it measures the same from each side of the shaft to the sides of the tool, and the tool will

be over the centre of the shaft and in a proper position to do its work. Key-ways are now usually cut on a milling-machine, but many small shops do not have one. In planing a key-way through a hole set the lower or cutting end of the tool at a point to correspond with the centre of the hole through which the key-way is to be planed; then measure from each side of the hole to either side of the tool, and move it until it measures an equal distance from the sides of the tool to the sides of the hole.

29. *Planing a T-shaped Slat.*

In planing a T-shaped slat or way, such as are used for slides, or on a planer-bed, to hold the head of a bolt, it is first necessary to plane to the desired depth with a square-end tool, and after doing this plane the upper part of the way to the desired width. Having done this, plane the bottom part of the way with two tools, one bent on a right angle, and the other to the left. And in planing large ways these tools should be made as small as they will stand without breaking, and should cut freely on each of the three sides. Make a sheet-iron gauge, and plane the way to it. In small shallow ways they may be planed the depth and upper width at once, and then finished with tools made the desired shape of the way.

30. *To Plane the Cross-head for a Planer, a Bed or a Table for Milling-machine, Lathe, etc.*

To begin this work first plane the top and sides of the guide nearly to the size required when finished. Next plane the outer sides at the bottom of these guide-ways on either side, taking off only a light cut up to the bottom of said guide-ways. Then turn the casting over and finish the opposite side. Next return the casting and bolt it down, then finish planing the guide-ways, but before doing this swing the block or head containing the tool-post inward at its lower end about half an inch and toward the side you intend to plane. Next unscrew the nuts on each side of the second head, upon which are the raised guide-ways, and swing it inward also at the lower end to the angle required while planing the said guide-way. On one side of this second head is a mark made at right angles with the guide-ways within it, and across the centre of a pivot on which the head swings, while on one side of the slide that moves longitudinally on the cross-head an index is made showing the various degrees on which the mark on the second head may be set while planing on an angle. After the two nuts on its outer sides are screwed up you will finish planing one side of the guide-

ways with a tool shaped for that special purpose. Next finish planing the outer surface up to the bottom of the guide-way. Then you will move the sliding head over to the other side of the ways, and swing the front and second head in an opposite direction, as before, and set up the screws over the swinging block that holds the tool-post, and the two nuts at the sides of the second head, and finish the opposite side of the guide-way and the lower surfaces up to the bottom of the said guide-way to the exact height of the one on the opposite side. And you will plane all of these surfaces as smooth as possible.

31. *Note.*

In planing metals, especially thin cast-iron surfaces, it is always necessary to plane over a cut on both sides, before finishing, either for the outside or scales. Being harder than the inside, the moment the scale is taken off the piece springs through the expansion of the scale on the opposite side. Hence the necessity of planing both sides before finishing either.

32. *Gear-cutting.*

In cutting gears they are reckoned a certain number of teeth to the inch, measuring across the

diameter to a certain line which is marked on the face or sides of the gear with a tool. This line is one half the depth of the teeth from the outer diameter. That is, if the teeth of the gear are two tenths of an inch deep, this line would be one tenth of an inch from the edge, and is called the pitch-line.

33. *Depth of Teeth.*

Every gear cut with a different number of teeth to the inch should be cut of a depth to the pitch-line to correspond with the number of teeth to the inch. This is called proportion. Therefore, if you cut a gear eight to the inch, the depth to the pitch-line should be one eighth of an inch, and the whole depth of the tooth should be two eighths. Again, if you cut a gear twelve to the inch, the depth to pitch-line should be one twelfth of an inch, and the whole depth of tooth two twelfths. And again, if you cut a gear twenty to the inch, the depth to pitch-line should be one twentieth of an inch, while the whole depth should be two twentieths, and so on, *ad infinitum*.

34. *Measuring to Find the Number of Teeth.*

To find the size a certain gear should be for a certain number of teeth is an easy matter if you

study carefully these rules. If you want a gear with thirty-two teeth, and eight to the inch, it should be four inches, measuring across the diameter to the pitch-line, and the two eighths outside of the pitch-line would make it four inches and two eighths. Again, if you want a gear with forty teeth, and ten to the inch, it should measure across the diameter to pitch-line four inches, and the two tenths outside the pitch-line would make the whole diameter four inches and two tenths. And again, if you want a gear with eighty teeth, and twenty to the inch, it should measure to the pitch-line, across the diameter, four inches, and the two twentieths outside the pitch-line would make it four inches and two twentieths, and these examples will form a rule for the measurement of all except bevel-gears.

35. *Bevel-gears.*

These are turned a certain bevel to correspond with each other, according to the angle upon which the shafts driven by them are set. For instance, if two shafts are set upon an angle of ninety degrees, the surfaces of the faces of these gears will stand at an angle of forty-five degrees. To get the surface of these gears in turning them put a straight edge across the face. Then set your bevel on an angle of forty-five degrees, and try the face of the teeth

by placing the bevel on the straight edge. After turning the face of the teeth square the outer diameter by the face of the teeth; and to get the size to which you wish to cut measure from the centre of the face of the teeth. Thus, if a bevel-gear is six inches in diameter, and the face of the teeth is one inch, you will measure from the centre of the face, and find it is five inches. On this line you calculate the number of teeth to the inch, and if you want a gear with twenty teeth, and ten to the inch, it should measure two inches across the face to the centre of the surface of the teeth; and if the face of the teeth were one inch in length the diameter of the gear would be three inches, and the inside of the teeth would measure only one inch. Again, if you want to cut a gear with forty teeth, and ten to the inch, it would measure four inches to the centre of the teeth on the surface. And if the surface of the teeth were one inch long the diameter of the gear would be five inches, while it would only measure three inches inside the teeth. These examples will form a rule for all bevel-gears.

Worm-gears.

In making these the teeth should at first be cut on centers having an index as shown on page 69,

and with a cutter about the size and shape of the screw or worm that is to move or feed the gear, and it should also be cut on an angle to correspond with the pitch of the worm that is feed the gear. The next operation is to place the gear on an arbor with one end made like a lathe-tool. This arbor is to be made on a right angle, and the round end is to stand upright or in a perpendicular position, while the opposite end is held in the tool-post of a lathe. The gear is then to run freely like a loose pulley on this arbor and is finished with a hob, and this hob is made the same size, and its teeth should be the same shape, as the worm or screw that is to move it; and this hob may be made of one piece, and its teeth are made about midway between its ends, one of which is used to hold a dog, and its ends are turned below the size of the bottom of the teeth of this hob, which is made similar to a tap; it may also be made short and have a hole through it and be keyed to an arbor, and this arbor should be long enough, so as not to run against the face-plate that drives it. The gear is then moved against this hob and cut therewith until its teeth are finished to the desired shape. The centres on the aforesaid arbor to which the hob is keyed should be countersunk very large in order to prevent breaking the centres of the lathe

in which it is run by the lateral or side pressure against them while finishing the gear.

36. *The Different Styles of Filing.*

To file a surface true it is necessary on commencing to squeeze the file tightly between your third and fourth fingers and the palm of your hand, until you become used to it. Your position in filing should be half left face to your work, with the middle of your right foot fifteen inches behind your left heel; and to file your work true or square it is necessary to reverse your work often, as by this means you are enabled to see the whole surface you are filing, and also to see, while filing, whether you are filing true or not. Where, however, your work is so heavy that you cannot reverse it, you had better file first to the right, and then to the left, as by this means you can plainly see the file-marks, and this again assists you in filing true.

37. *To File a Square Hole.*

To file a hole square it is necessary to reverse the work very often. A square file should first be used, and the holes finished with either a diamond-shaped file or a half-round one. This leaves the corners square, as they properly should be.

38. *Draw-filing and Finishing.*

To draw-file a piece of work smoothly and quickly it is best to first draw-file it with a medium fine file, and finish with a superfine file. After doing this polish the work with dry emery-paper, and then with emery-paper and oil.

39. *Lining Boxes with Babbitt Metal.*

To line boxes properly, so as to insure their filling every time, it is necessary to heat the box nearly red-hot, or at least hot enough to melt the metal. Then smoke the shaft where the metal is to be poured upon it. This insures its coming out of the box easily after it is cold. After smoking the shaft put it into the box or boxes, and draw some putty around the ends of them for the purpose of stopping them, taking care not to press upon it, for if you do it will go into the box, and fill a place that ought to be filled with metal; and in the meantime your metal ought to be heated, and after you have poured it let the box stand till it is nearly cold; drive out your shaft, and it is done.

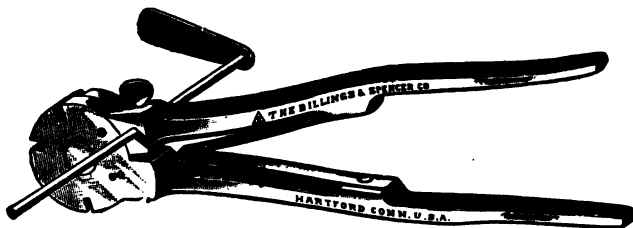
40. *Making Lining-metal.*

Melt in a crucible one and a half pounds of copper, and while the copper is melting melt in a ladle twenty-five pounds of tin and three of antimony

nearly red-hot. Pour the two together, and stir until nearly cool. This makes the finest kind of lining-metal.

41. *Putting Machines Together.*

In putting machines together no part should be finished except where it is necessary to make a fit, as it is sometimes the case that machinery is mis-



Tool for Cutting Wire.

calculated, and by finishing it would be spoiled, while if it were not it might be saved by slight alterations in design. And again, in finishing certain parts before you get a machine together you are unknowingly finishing parts not necessary to be finished, and making them of a shape anything but desirable. This rule, however, is not intended to apply to machinery being made to detail drawings.

42. *Working Steel for Tools.*

In working steel for tools great care should be taken to hammer all sides alike, for if one side is

hammered more than another it will cause it to spring in hardening. Again, steel, when being hammered, should be heated as hot as it will stand until finishing, and should then be hammered until almost black-hot, for the reason that it sets the grain of the steel finer, and gives the tool a better edge. The reason for heating the steel so hot while hammering is simply because it makes the steel tougher when hardened, and softer when annealed; while if it were worked at a low red heat the continued percussive shocks of the hammer would so harden it as to make it almost impossible to anneal it, and at the same time render it brittle when hardened.

43. *Annealing Steel.*

In annealing steel it should be heated as slowly as possible to a red heat, but never hot enough to scale, and should then have three hours or more "to cool in." A piece of steel that is heated hot enough to scale can never be annealed well without working over, and is always rendered glassy, and bad to work. To prove this take a steel shaft and heat it in several places hot enough to scale, and in several others to a low red heat. Allow it to cool, and when you turn it you will see at once that the places heated hot enough to scale are considerably

harder than those heated properly. All tools that are required to be hardened without springing, as cutters and reamers, should be turned to about one sixty-fourth of an inch of their size, and then annealed before finishing. This takes the strains out, so that when they are heated for the purpose of hardening they will not spring.

44. *Water-annealing.*

Heat the steel to a red heat, and let it lie a few minutes, until nearly black-hot, then throw it into soap-suds. Steel used in this way may be annealed softer than by putting it in the ashes on the forge.

45. *Hardening Steel Tools of the Various Kinds.*

All steel tools should be hardened at a low red heat, or the lowest heat at which they will harden, and the larger a piece of steel is the greater the heat required to harden it. This is on account of its taking longer to cool, for the moment a large body of heated steel is plunged into the water the steam arising from the surface of the steel blows the water away from it, and thereby causes it to take more time in cooling. For instance, an anvil heated red-hot and thrown into a hogshhead of water would, instead of hardening, blow the water away

from it and cool slowly, until the water boiled, and when taken out would be as soft as before it was heated. Hence the necessity of hardening anvils under a jet of water, or a waterfall. Very small tools, as needles and centre-drills, penknives and lancet-blades, should be hardened in oil, or in hot water, as by cooling in cold water they cool too quickly, and are either rendered brittle, or cracked, so as to be worthless. This is also the case in hardening springs — they are almost invariably broken when hardened in cold water, and therefore should be hardened in oil. I have a razor which, being too soft, I hardened in oil—after being concaved—without springing in the least, and it is now as good a razor as I ever used. A piece of steel for a tool of any kind should never be heated hot enough to raise scales on it, except where it is so large that it will not harden without; for steel when hardened at that heat is rendered coarse in grain, and brittle, and you may draw the temper of it to a straw-color, and it will still break more easily than a piece hardened at a low red heat and not drawn at all, and at the same time the piece that is heated hot enough to scale, and drawn, will be softer than the piece hardened properly. Hence it is necessary to take great care in hardening steel for tools.

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46. Dipping Tools When Hardening.

To harden a penknife-blade, lancet, razor, chisel, gouge-bit, plane, spoke-shave, iron-shaving knife, three- and four-square files, and round and flat files, dip them endwise or perpendicularly. This keeps them straight, which would not be the case were they dipped or put into the water otherwise

47. Dipping a Half-round Reamer.

To dip a half-round reamer, or any tool that is solid and half round, dip it with the half-round side twenty degrees leaning towards the water. This hardens it nearly straight. It is necessary here to remark that the surface of any piece of steel that is half round has half as much again surface on the half-round side to be hardened as the flat side has, and the contraction of the steel being equal, according to the surface, the necessity of dipping the half-round side at an angle is apparent. That is, a half-round surface tending to one point, which is or has once and a half the surface or power of contraction as the flat side. This contraction is what draws a piece of steel to one side, and makes it spring.

48. Dipping a Fluted Reamer Properly.

Dip it perpendicularly to a short distance beyond the fluting—that is to say, about half an inch, and

done

withdraw and return it several times. This hardens all the lips, and prevents its cracking off at the water's edge, which is the case when a piece of steel is dipped in to a certain depth, and allowed to cool without moving. Arbors or mandrels are often broken off at the ends in this way, without the workman's knowing what caused them to crack.

49. *Tempering Tools.*

Drawing the temper of tools is usually done in a charcoal flame, and to draw the temper of a tool properly the thickest part, or the part not requiring any temper, should be held toward the fire, and in the meantime should be often wiped with a piece of waste or a rag dipped in oil. The oil keeps the temper even, and prevents its drawing more in one place than another. And in drawing the temper of any tool it should be drawn very slowly,—otherwise it will run too far ere you are aware of it. Lancet-blades and razors should be drawn to a straw-color. Knife-blades and chisels should be drawn to a copper or almost red color. Plane-irons, shaving-knives, and shoemakers' knives the same temper. Cold chisels and stone-drills should be drawn to a dark blue. Fluted reamers should only be drawn to a straw-color on the end, as they never break elsewhere, and keep their size

longer by leaving the lips hard. Half-round or tapering reamers, also taps, dies, and drills, should be drawn to a straw-color. Jigs and gauges, also common lathe-tools, need no drawing, being tempered enough when merely hardened.

50. *Fancy or Special Tool Making.*

Probably no profession among the fine arts is more "scientific," or requires greater care, than the art of gun, and watch, or fine special tool making, and it is safe to say that not one machinist in five hundred will make a *good* tool-maker. We will now commence on—

51. *To Make a Collet or Drill-socket.*

In order to make these tools properly first centre and square the ends of a piece of steel that you



A Collet or Drill-socket.

intend to make it from, and have the piece of steel three eighths of an inch longer than it is to be when finished ; then turn the end that is intended to fit a certain lathe or upright drill where it is to be used, leaving it a sixteenth larger than it is to be

when finished. Next turn the outer end in order that it may be run within a back-rest. Then screw the shank-end into the jaws of a chuck on an engine-lathe, and the outer end within the slides of a back-rest, said rest to be screwed to the ways of the lathe, and screw the still centre into the outer end of the piece intended for the collet. Then screw the slides within the back-rest inward until they touch the collet; but before setting the piece to be drilled be sure that the centres are set in a line, or so they will turn a piece of steel or shafting perfectly straight. Having got your work in position, drill a hole in the outer end in size the same as the small end of the shanks of the drills to be fitted to it. Now with a tapering and fluted reamer you will ream the hole nearly to the size required and finish by the hand, holding the socket within a vice. Unless you do this, the hole will not be reamed straight, as no lathe was ever made having its spindles on a perfect line. Now make an arbor long enough when fitted to the collet to extend six inches beyond the outer end of the collet, and have this outer end turned straight its whole length. Next put the arbor into the collet, then put its shank-end and the arbor within it on the centres of a lathe, and with a square-end tool try the arbor near the outer end of the collet to see

if it runs true; if not, cut the shank-end on one side with a countersink placed within a chuck and the arbor on the still centre of a drill-lathe, and continue this cutting until the arbor near the collet is perfectly true. In doing this cutting it may be necessary to square off the shank-end of the arbor so as to nearly square the countersunk centre out. This occurs only when the hole is drilled by a boy, as I have seen them drilled in spindles for lathes. It is better, however, to drill the hole in a collet or a spindle below size, and then bore the hole with a tool before reaming nearly to the size required before reaming it, as it saves time both in reaming and in cutting the side of its centre to get the hole true. Before turning or fitting the collet redrill the centre at its shank-end with one or more larger drills than the centre-drill used before it was gouged or cut to one side, as these drills, being somewhat larger, will follow the countersink, this being necessary in turning the shank tapering in a lathe with the still centre set over to one side. As the point of the centre will follow or be guided by this hole, you cannot turn the shank true if this hole is not true with the countersink. After this is done, and with arbor within the collet, turn it to fit the lathe or upright drill where it is to be used. And then turn another chip off about a thirty-

second of an inch, or enough to allow the end to enter the key-way in the spindle about three eighths of an inch, and finish the outer or drill end. Next with a small cutter mill off two sides of the shank-end so it will enter said key-way. This key-way in a collet begins at the end of the hole therein and is cut through solid metal.

52. *Making Arbors.*

Arbors upon which gears, pulleys, or other work is turned should at first be centered, drilled, and countersunk very lightly and then have the ends squared, taking out all of the countersink, unless, however, the ends are true before they were countersunk, for if the ends of an arbor were tapering the countersink would run to one side of the hole and the arbor would wear to the side where the countersunk part is shortest. The lip or lips on a countersink should be turned to fit a triangular gauge, and the centres on which an arbor is turned should be turned to fit this gauge, and the size of the countersink on the ends of an arbor should, in order to have it wear well, be one third the size of the ends of an arbor of any size when finished. Before turning an arbor ends next the countersunk part should be cut slightly under in order to prevent the sink from being bruised when driven out or in by a

boy or a cheap workman. The ends should then be turned about a twentieth of an inch below the size of the arbor when finished, and from the ends the breadth of the dog that is to drive it. Then round the corners off on its ends and file a place for the set-screw. Next harden and draw ends to a straw-color, and next grind the countersunken ends with emery, and oil on the dead centre of the lathe you intend to turn it on. Then turn it throughout its length a fiftieth of an inch above size, and then turn one of its ends to fit the gauge or wheel to be turned on it, and no farther from said end than the length of the hole within the wheel you intend to turn. The reason for this is after an arbor has been used a few hours it will be found to either have sprung or have the centres worn to one side; then that portion that you have left above size may be either turned or ground to size. Arbors to be ground should first be turned a twentieth of an inch at midway from the ends above size, as they will spring when they are hardened; it may be well, however, in order to save grinding to turn them at the ends nearly down to size, and leave them larger at midway between the ends. Arbors to be ground should be hardened throughout their length and have the ends drawn to a straw-color, while the body, or all but the ends, may be drawn to a dark

blue or almost a red color, the ends being left harder in order to make them wear longer.

53. *Eccentric Arbors.*

Arbors upon which eccentrics are to be turned should have the centres drilled five eighths of an inch deep, and with drills of two sizes, as the first will run to one side from the pressure against its end. Then it should be countersunk very lightly and the ends squared, and then be turned straight from end to end about a fiftieth above size. Then the countersink should be squared or cut nearly out, and the ends filed very smooth, and be coated with sulphate of copper, which is blue vitriol, in order that the marks to be scratched can be plainly seen. Then with a tool having a sharp end and held within the tool-post draw a small line on one side from end to end. Next place it upright in a vise and insert within the hole the shank-end of the drill that it was drilled with. Now place a straight-edge against the line drawn on the outside of the arbor and against each side of the drill, and scratch two lines to meet at the one drawn on its outside. Next measure the throw desired from the side of this drill, and make a line across and at a right angle with the other two lines. Then deduct one half the size of the drill, and make another line in-

side the one you have drawn and toward the centre. Then with a sharp centre punch mark it lightly on the inside line and between the other two lines that run from the outside line to the sides of the drill, but before you drill this second hole for the eccentric make semicircles with dividers across the lines running from the drill to the line on the outside of the arbor, using the mark made with the centre-punch as a centre to strike the semicircles from, and use these four lines as guides for the centre-drill. Next countersink the centres and turn the arbor to the size required, and then countersink the holes to be used for turning the eccentric quite large, and if the sink has not room without running into the other hole square from the end of the arbor until you can sink it to the desired size. Next turn down the ends for the dog and file a place at each end for the set-screw; take off the corners; then harden and draw the temper to a straw-color. The arbor may if you desire be turned to size before the holes (eccentric) are set off.

54. *Making Drills.*

There are numerous styles of drills. Every drill should be made straight on the sides of the lips for at least half an inch from the end. This prevents their running under or to one side. To

Flat Drill for Chucking.

Flat Drill for Chucking.

A Tap- or Reamer-wrench.

this rule, however, we will except very small drills, as they would, if made in this way, soon get broken by the small particles of iron-dust that force their way between the sides of the drill and the sides of the hole being drilled.

55. *Spiral Drills.*

To make a spiral drill anneal it and turn it one fiftieth of an inch larger than you intend it to be when finished. Then heat it again,* and anneal it in a perpendicular position, either by putting it into lime or ashes in an upright position, or dipping it into soap-suds. After doing this turn the shank

* The reason for again heating a piece of steel after partially turning it is simply because it is often hammered harder on one side than the other, and the turning it true frequently takes more stock on one side than the side opposite. This leaves the side from which the lightest chip is taken much harder than the other, and this is the principal cause of a reamer or other slender tool's springing when it is hardened. Again, annealing tools in a perpendicular position is better than to lay them on their sides, for the reason that they sometimes lie with their weight at each end, and this will always spring a reamer or other slender tool. Almost every one has seen a board lie with its weight resting upon its two ends, and that its own weight caused it to settle in the middle. Upon this principle a piece of steel will settle when annealing if not placed in a proper position. But if dipped into the water perpendicularly the result will be that when it is hardened it will spring or strain itself to its proper position.

to fit a certain collet, socket, or chuck (the names are various in different shops), and after doing this you may turn the point or end to the desired shape and size. Then, measuring from that point, turn it tapering, one hundredth of an inch smaller for every two inches of the drill's length, and the turning part is done. Spiral drills are now left above size and are ground after being hardened to size.

56. *Cutting the Spiral Grooves.*

This is done in a machine made for the purpose, which contains a spindle, which revolves slowly while the grooves are being cut. This spindle also slides slowly while grooves are being cut, and contains a screw, upon the end of which is fastened a chuck for holding the drill. You will put your drill into this chuck, and raise the sliding block which is beneath the drill until it touches the drill, taking care not to raise it too high, so that the drill shall be raised above the centre of the chuck into which it is screwed. Having adjusted your machine, you will put in a cutter, and groove your drills as follows: For drills one eighth of an inch in diameter cut them one to the inch, calculating as you would in cutting a screw to an engine-lathe, and the depth of the groove should be cut to within one hundredth of an inch of the centre

of the drills. For drills one half an inch in diameter one and a half to the inch, and down to within a sixty-fourth of the centre. Drills one inch in diameter should be cut one to the inch, and down to a thirty-second of the centre. The index plate will give you the two opposite points from which to commence cutting.

The thickness of the cutter should be one half the diameter of the drill, and the edge of the cutter or teeth should be rounded to suit the various sizes of drills, as may be required. (See Appendix.)

57. *Flat Drills for Chucking.*

Such drills should be made of three lengths only. That is, when a lot is made for a shop, all sizes of three fourths of an inch and above should be made thirteen inches long. All sizes from three fourths down to three eighths of an inch ten inches, and sizes below that five inches long. This saves the time usually lost in moving your puppet-head when drilling your hole with several drills of different sizes. As these drills are made to be followed by certain-sized reamers, they should be made exactly one hundredth of an inch, at their ends, smaller than the reamer designed to follow them, and should be tapering, so as to measure, at a distance of three inches from the ends, one

hundredth of an inch smaller than at the end. Then taper the corners. Draw-file the edges, the same shape as turned by the lathe. Such drills should never have their edges filed square, as they are made in some country shops, for it is impossible to drill two holes of a size with drills made in this way. The more nearly square such drills are made on their ends the longer they will wear. It is necessary, however, to take off the corners. In hardening such drills it is not necessary to draw the temper, as they never break, and it is my philosophy never to draw the temper of a tool that is not liable to break, for the harder they are the longer they will wear.

58. *Tap and Reamer Wrenches.*

Tap and reamer wrenches should be made square in the middle, and should have a square hole punched or cut through the square to hold the head of the tap or reamer, while the ends should be turned round to within half an inch of the hole in the middle.

59. *Proportions for Tap- and Reamer-wrenches.*

Very small taps should be used in file-handles. Wrenches for taps and reamers from one eighth of an inch to five sixteenths should be five inches

long, with a square in the middle half an inch in diameter, and a square hole cut through it three sixteenths of an inch in diameter. The ends are to be turned rounding, half an inch at extreme ends, and five sixteenths near the whole in the middle. The extreme end should be rounded with a hand-tool and polished so as not to hurt the hands of the user.

60. *Tap- and Reamer-wrenches, Size Two.*

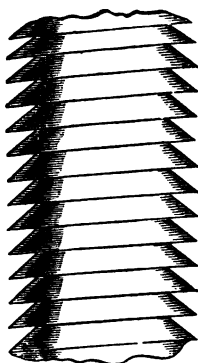
Wrenches for taps and reamers from five sixteenths to seven sixteenths should be ten inches long, with a square in their middle five eighths in diameter, and a square hole through square five sixteenths diameter. Ends round, five eighths by seven sixteenths.

61. *Tap- and Reamer-wrenches, Size Three.*

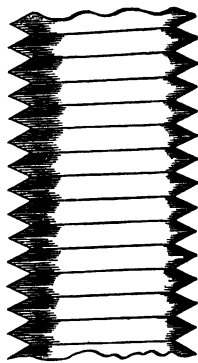
Wrenches for taps and reamers from seven sixteenths to five eighths should be fifteen inches long. Square in middle, seven eighths. Hole through square, seven sixteenths. Ends turned rounding, three fourths by nine sixteenths.

62. *Wrenches for Taps and Reamers, Size Four.*

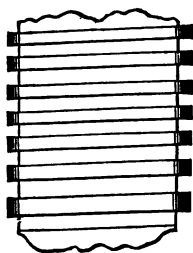
Wrenches for taps and reamers from five eighths to thirteen sixteenths should be twenty-



A Screw for Great Strength.



A V-thread Screw



A Square-thread Screw.

four inches long. Square in middle, seven eighths by one and one eighth inches. Hole through largest way five eighths. Square ends turned seven eighths by eleven sixteenths.

63. *Wrenches for Taps and Reamers, Size Five.*

Wrenches for taps and reamers from thirteen sixteenths to one inch, thirty inches long. Square in middle, seven eighths by one and three eighths. Hole in square, thirteen sixteenths. Ends round, seven eighths by three fourths.

64. *Wrenches for Taps and Reamers, Size Six.*

Wrenches for taps and reamers from one inch to one and a fourth, forty inches long. Square in middle, one inch and five eighths by one inch. Hole



A Tap with Sliding Guide.

through square, one inch. Ends turned, one inch by seven eighths. Tap- and reamer-wrenches are now generally made with adjustable sliding jaws that are moved by a screw so they will fit many sizes of taps or reamers.

65. *Making Taps. The Turning.*

This is a process requiring care, and every tap should have immediately under its head or square for the wrench a place turned exactly the size of the outside of the thread. You have then no trouble in getting the size of the threads when they have an odd number of flutes in them. Every tap should also be exactly the size of the bottom of the thread, from the termination of the thread, which is usually about midway to within about half an inch of the head or



A Standard Thread-gauge.

square. This you will leave to get the size of the bottom thread. It is a foolish error in tool-makers to make a tap stiff above the termination of the thread, for the reason that when in tapping a hole you come to a sudden stop the tap is sure to break, when, if it were turned straight from the terminus of the thread nearly up to the head, it would twist instead of breaking.

66. *Proportions of Screws.*

The sizes marked below one fourth of an inch in this schedule are in proportion to the strength of the screw, and as they are mostly used with a handle similar to a file-handle, but octagonal in shape, I think them fully coarse-threaded enough for all purposes. The numbers marked coarser than seven to the inch are calculated for square-thread screws.

Screws of one sixteenth of an inch in diameter, fifty threads to the inch.

Screws of one eighth of an inch in diameter, forty to the inch.

Screws of three sixteenths of an inch in diameter, thirty to the inch.

Screws of one fourth of an inch in diameter, twenty-five to the inch.

Screws of five sixteenths of an inch in diameter, twenty to the inch.

Screws of three eighths of an inch in diameter, seventeen to the inch.

Screws of seven sixteenths of an inch in diameter, fourteen to the inch.

Screws of half an inch in diameter, twelve to the inch.

Screws nine sixteenths of an inch in diameter, twelve to the inch.

Screws five eighths of an inch in diameter, eleven to the inch.

Screws eleven sixteenths of an inch in diameter, eleven to the inch.

Screws three fourths of an inch in diameter, ten to the inch.

Screws thirteen sixteenths of an inch in diameter, ten to the inch.

Screws seven eighths of an inch in diameter, nine to the inch.

Screws fifteen sixteenths of an inch in diameter, nine to the inch.

Screws one inch in diameter, eight to the inch.

Screws one and one sixteenth inches in diameter, eight to the inch.

Screws from one and one eighth to one and one fourth inches in diameter, seven to the inch.

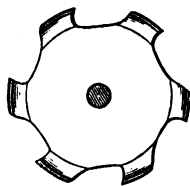
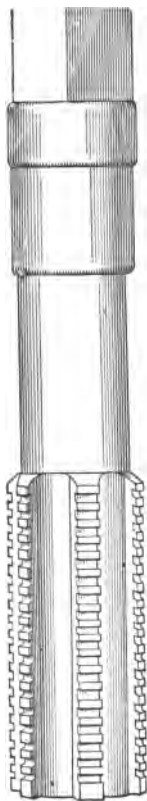
Screws from one and one eighth to one and one fourth inches in diameter, seven to the inch.

Screws from one and five to one and seven sixteenths inches in diameter, six to the inch.

Screws from one and a half to one and eleven sixteenths in diameter, five to the inch.

Screws from one and three fourths to two inches in diameter, four to the inch.

Side View of a Square-thread Tap for Left Hand.



End View of a Tap Properly Fluted for a Left-hand Tap.

67. *Making Taps.*

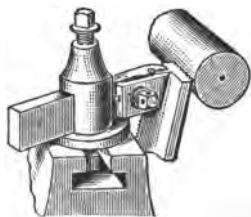
In cutting a tap for V-shaped threads they should be finished with a tool made to fit a triangular gauge, and if they are cut sharp the depth of the thread should be equal to the pitch. This means if a tap is cut ten to the inch it should be cut a tenth of an inch deep. This rule applies to taps of any pitch, and all taps should be cut to a standard thread-gauge. This is a piece of steel with a number of threads cut on one edge or end of it with a standard tap or hob, and is marked to show the number of threads to



Rhodes Threading-tool with Stock.

the inch. By using this gauge a tap may be cut without having the thread lean to one side like teeth in a carpenter's saw. Another standard gauge is made solid and has a thread cut through it, and used to keep the tap or a screw to a standard size. After the thread on a tap is cut it should not be polished

with emery, as this causes it to glaze between the threads, and this glazing will make it cut or move much harder than if the threads were not covered with a glaze. Taps to be used in a lathe and having coarse threads should have the taper from the ends double the length of those used by the hands, and the length of the thread should be somewhat longer also than those used by hands; then as the lips become dull they can be ground sharp. The size of these taps above the thread should be the



A Chaser with Stock, Tool-post Block, etc.
(P. & W. Co.)

same as at the bottom of the threads, and the length of the tap above the thread should double the length of the taper; then a half dozen nuts can be tapped before it is taken from the jaws of the chuck. The upper ends of these taps should be squared in order that they may be held without screwing the jaws of the chuck down too firmly.

In making a tap for cutting solid dies that are to be used for cutting coarse threads on rough unturned bolts or screws they should be made a fiftieth of an inch above the size that such bolts are supposed to measure, for the reason that round iron from which bolts and screws are made varies and is often larger than the size they are sold for. The same-sized tap should be used while tapping rough nuts for these bolts.

68. *Taps with Square-threads.*

Taps with square threads and designed for strength should be cut one half the depth of their pitch. Therefore, if your thread is five to the inch, you will cut it one tenth of an inch deep. Your threads being five to the inch, there would be a space between the threads one tenth of an inch, and the thread being one tenth wide and one tenth deep, would form the square thread. Square threads for wear, however, should be cut three fourths the depth of their pitch.

69. *Mongrel, or Half-V, Half-square Threads.*

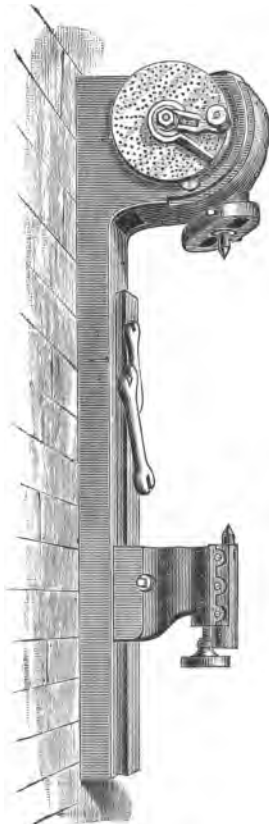
These threads, made for great wear, are difficult to cut. They should be cut the depth of their pitch, and for extra great wear, where a screw is required to be kept accurate for a long time,—such

as the lead-screw for a lathe,—they should be cut once and one half the depth of their pitch. The outside of the thread, and also the bottom of the thread, should be in width one fourth of the thread's pitch. Therefore, if you were cutting a screw five to the inch, it should be one twentieth in width on the outside, and one twentieth at the bottom of the thread.

70. *Fluting Taps.*

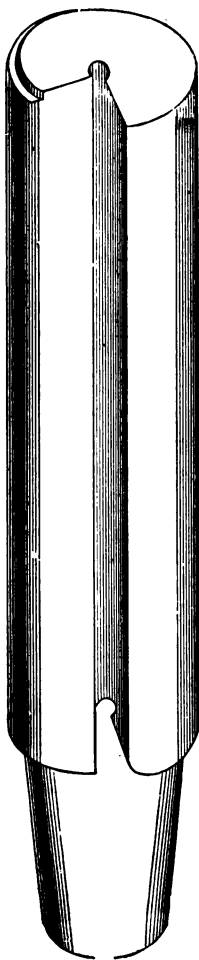
Every tap should be fluted with the teeth a little hooking on the face. That is, in striking a line through the middle of the tap, on the end, the flute or groove should be inside that line, while the flute at the outside of the thread is exactly *on* the line. The back side of the teeth, however, may lean a little outside of the centre, but not enough to allow the dust to ride over when backing out the tap. It is needless to say that it is impossible in steel to cut a coarse thread full with a tap that has the faces of its teeth leaning backwards without tearing out half the threads, for taps made with the faces leaning backwards, do not cut, they merely stretch and tear the thread to its size instead of cutting it. It is, in fact, upon the principle of turning a shaft with a square-end tool, with the point or end leaning downward.



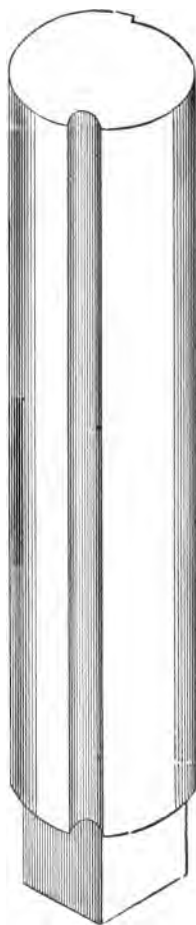


Elevating Centres with Index for Cutting Gears, Taps, Reamers, Mills, etc.
(Pratt & Whitney Co.)

A Drill with a Single Lip, for drilling holes very straight.



A Reamer with Single Lip, usually made half round.



71. *How to Go to Work.*

Set your tap on the centres, and with a cutter or a planing-tool made round at the end, and the thickness of the end one fourth the diameter of the tap, plane or mill the faces of all the teeth one half the depth of the thread below the bottom of the thread. For instance, if a thread is an eighth of an inch deep, plane or mill it one sixteenth below the bottom of the thread. After planing all the faces or milling them all to their depth, plane or mill off the back sides of the teeth, leaving them once and a half the breadth of their pitch. Thus, if the pitch is ten, leave them a tenth, and a twentieth breadth. This leaves fully stock enough for strength, and the less bearing a tap has the more easily it turns. The back sides of the teeth should be finished with a cutter or planing-tool, made in thickness of the size of the tap. It is economical to have two taps for every thread, and have the first one small enough to cut only two thirds of the thread, and the second to finish. Taps for fine threads made in this way need but little taper at the end. They never go hard, and do not get broken half so often as when they are both of one size. Very large mongrel-thread taps should always be of two sizes at least, for the threads being so coarse, and there being so

much more so, and it would be almost impossible to cut the threads of worms without tearing them. For hardening or tempering taps see articles on "Hardening and Tempering Tools."

72. Fluted Reamers.

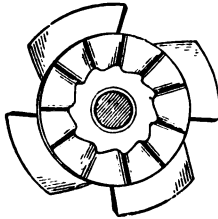
Fluted reamers should first be turned to within a thirty-sixth of an inch of the required size, and then heated and allowed to cool in an upright position before using. This takes out the strains, and the flutes are formed in places by hammering out, so that they will not spring when heated for hardening. In doing this care is only fluting them with an old hammer, and not preventing them from chattering as not sufficient. For when a



A Fluted Tap Reamer.

reamer chatters it must be rejected; hence it is necessary to make the reamer true. Flutes in reamers from one fourth to three eighths of an inch in diameter should be five. The number in reamers from five eighths to one inch should be seven. The number in reamers from one inch to one and a fourth should be nine. The number from one and a fourth to one and a half inches should be eleven.

End View of a Counter-boring Tool.



Side View of a Counter-boring Tool.



much metal to cut out, it would be almost impossible to cut the thread otherwise without tearing them. For hardening and tempering taps see articles on "Hardening and Tempering Tools."

72. *Fluted Reamers.*

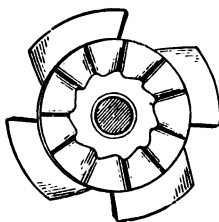
Fluted reamers should first be turned to within a thirty-second of an inch of the required size, and then heated and allowed to cool in an upright position before finishing. This takes out the strains, and the hardness made in places by hammering out, so that they will not spring when heated for hardening. In fluting reamers merely fluting them with an odd number in view of preventing them from chattering is not sufficient. For when a



A Fluted Taper Reamer.

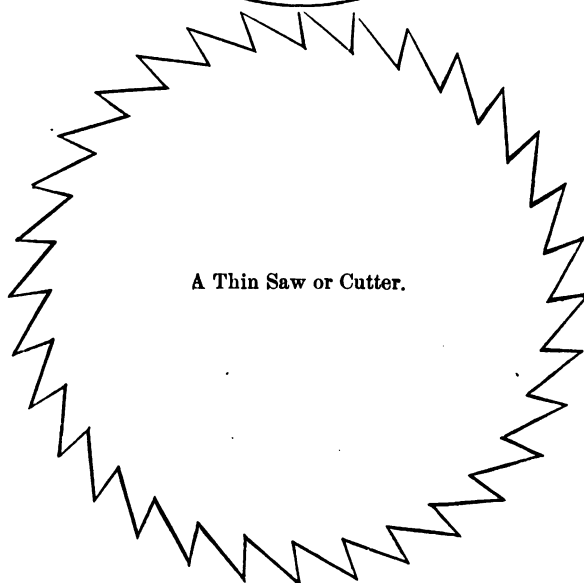
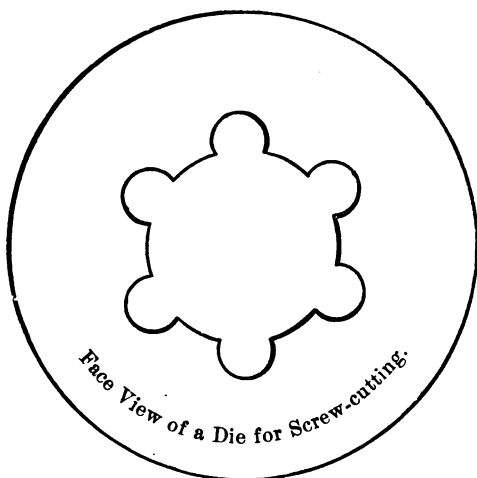
reamer chatters it jumps from lip to lip; hence it is necessary to make the lips uneven. Flutes in reamers from one fourth to five eighths of an inch in diameter should be five. The number in reamers from five eighths to one inch should be seven. The number in reamers from one inch to one and a fourth should be nine. The number from one and a fourth to one and a half inches should be eleven.

End View of a Counter-boring Tool.



Side View of a Counter-boring Tool.





73. *How to Make a Fluted Reamer.*

Have the head forged nearly to size required. Then make good centres in it, for these are necessary to keep it true. Turn it to within a thirty-second of the required size, then heat it and let it cool in an upright position. Then turn the part designed for the lips a sixty-fourth of an inch larger than the size at which you intend to finish it, then turn a place in the middle of it five eighths long, and one twelfth of the reamer's size smaller than its lips. This is the place to pene it straight



A Fluted Shell Reamer.

after hardening. After turning all but the upper part (which is to be turned after it is hardened and straightened) you commence fluting it by putting it on the centres, and if you flute it on a planer use a round-end tool one tenth of an inch in thick-

ness, and plane it down to the face of every lip, down to the bottom of the place made for pening, and plane them so that in every other one of the lips the space between them will be shorter than that of the one preceding it. After doing this use a square-end tool, and plane off the back side of the lips up to within a thirty-second of an inch of the face. The faces of these lips should be planed straight with the centre. File the lips smooth, then harden it. For hardening it see articles on "Hardening and Tempering Tools." Then pene it straight. Then turn the upper part to the size required and polish it. And then grind the lips down to size, and have them sharp, and it is finished. The flutes in reamers are now milled.

74. *Half-round Reamers.*

Half-round reamers should never be made in this age, but should be superseded by one with a single lip and made in the following style: Get a piece of steel, and have the head forged for a certain wrench, and turn it tapering and perfectly round. Then put it on centres, and with a small round-point tool plane or mill a groove through the whole length of it. One side of this groove forms the lip. Then from this groove plane or mill off a thirty second of an inch half-way round.



File up the face of the lips, on a line through the centre, on the end. Harden and temper. They should afterward be ground to proper shape.

75. *Rose Reamers.*

Rose reamers may be either hollow or solid: those of large sizes are usually hollow, and several sizes should have the holes through them of one size, so as to fit one shank. These reamers should be about three inches long, and have a slot cut across the centre at the inward end beyond the lips, and are supported by a pin through the shank



A Fluted Reamer to be Used for Chucking.

or shaft to which they are fitted. The lips of large rose reamers should be about ten to an inch, measured the same as gears are cut (see "Gear-cutting"), and their lips may be backed off slightly to within an eighth of an inch from their faces, but never brought to a sharp edge like hand-reamers, as in chucking a hole it would ream larger on the outside than on the inside, and in order to ream a hole smooth the ends of the lips should be rounded and not cut square with a side-tool. The sides of the lips may be made slightly tapering for

about three eighths of an inch from the end, and the taper should be brought to a sharp edge like the corners of the lips. With a reamer made in this way it will ream a hole as smooth as a hand-reamer, and it will keep its size five times longer than a hand-reamer. The inward end of a chucking-reamer opposite the cutting-end may be somewhat less in size than the end that does the cutting, or about one hundredth of an inch in a foot, for the reason that the centres of a lathe are never on a perfect line. These reamers should be straight, however, for about three fourths of an inch above the taper at the end. Small rose reamers of five eighths of an inch in size and below should have four lips, and very small ones only three; these lips should be cut well up on the sides to prevent them from sticking; their lips require no backing off.

76. *Counter-boring Tools.*

These tools should have a hole chucked at the cutting-end several sizes below the hole that is to guide the counter-boring tool. Then the guide at the cutting-end may be of many sizes, and fit many-sized holes, while that portion of these guides that enter the hole are to be all of one size, and should be fitted to drive lightly or so they can be wrung from the body of the tool and others inserted in

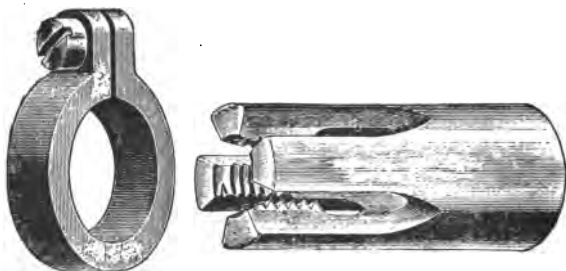
their place to fit a hole of another size. The upper portion of these guides are turned up to a shoulder, and to about half an inch or less from the outside, or according to the size of the tool. This also gives the workman a better chance to file the cutting-end or lips to a perfect and true edge. The lips on their sides may be an inch or less in length, according to their diameter, and they should be milled out diagonally in order to give a shaving cut and also a better clearance for the chips. Above the lips large sizes may be turned one fourth less in size than the diameter of the lips; these large ones usually have the shank-end fitted to a collet, while small ones must be solid or of one piece.

77. Making Dies for Screw-cutting.

In making dies to be used in a screw-machine first get a piece of octagon steel that is annealed and about a sixteenth of an inch larger than it is to be when finished, and also large enough to be turned to fit the stock or die-holder. Then centre and square its ends. Next drill a hole through it from one end the size of the bottom of the thread on the tap you intend to use in tapping it. Next enlarge this hole to about a thirty-second of an inch larger than the outside of the thread on the tap to within an inch from the end within which the

thread is to be. Then turn and fit it to the stock that is to hold it. Then with the tap held within a chuck and on a lathe and the end that is to be held within the stock is to be placed on the still or dead centre and tapped out. Then the lips are to be cut or milled on its front end and on its sides into the bottom of threads for about half an inch or less beyond the threads, according to the size it is tapped. And these lips should be three or more, according to the size of the tap used in tapping it.

Of other kinds of dies to be held within a stock one



Spring Threading Die with Collar. (Pratt & Whitney Co.)

is to be used with the hands and one kind is round and is held in a stock having handles, which across its centre should be made an inch larger than the die that is held with set-screws. This portion of the stock should be three fourths of an inch thick, and should be counter-bored five eighths of an inch deep

from its surface. Then these dies should be an inch long and have three or more slots cut in them to form the lips, and before these slots are cut holes should be drilled through them nearly to the bottom of the threads, and these holes should be about one third the size of the hole within which the thread is cut, and the hole within which the thread is cut should be made tapering from the bottom of the thread about half-way through the die. This is done to make it cut on a line parallel with the sides of the screw. It can then be reversed if desired when the thread is to be cut up to a shoulder, or as in a stud that is larger than the screw. It is then broached out between the threads and enough filed from the lips to leave no film or bruise caused by said broach. Between these lips a thin slot is cut throughout the length of the die; this is done to spring the lips together as they become worn, and the die should have small holes drilled on opposite sides about an eighth of an inch deep for set-screws; these holes should be drilled through the stock and into the die within it an eighth of an inch.



A Solid Die
for Hand-
stock.

Still another kind of dies are made to be used with the hands. These are oblong and square on their ends and sides. They are of two pieces and

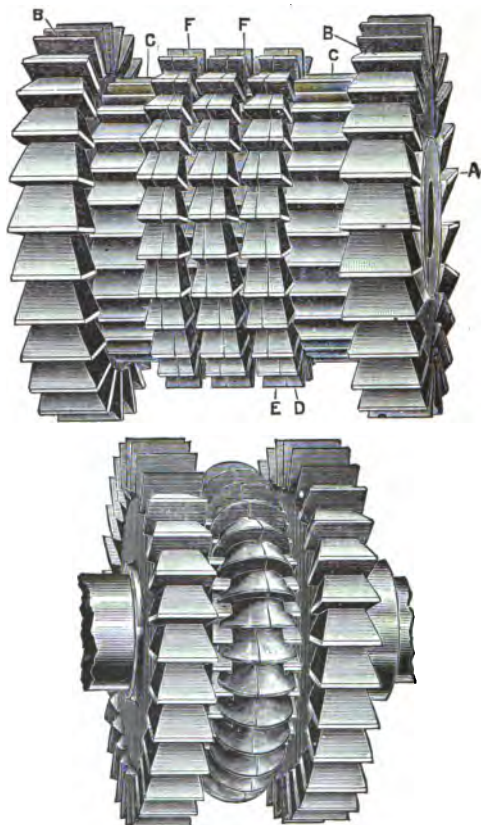


Adjustable Threading Die and Head for a Bolt-cutter



Stocks, Taps, and Dies with Case.

are screwed together with a set-screw, and should be held within the stock while the thread is cut. These dies should, in order to have the threads cut parallel with the sides of a bolt or screw, be made about three fourths of an inch thick, and in making these they should first be planed to fit within the stock. Then they should be cut at both ends an eighth of an inch down from their faces on both sides an eighth of an inch from their ends. This leaves the ends half an inch thick, and is done to save the stock that holds them from being too heavy. After the thread is cut at midway a space is filed to let the chips out and also to form four lips, and these spaces should be wide enough in large dies to leave the breadth between the ends of the thread not over a half inch, and these spaces should be filed tapering from the centre in order to let the chips out freely. These dies are intended for a stock having strips of thin steel screwed on both sides of the stock to secure the dies therein. Another way of making these dies is to cut a slot through each end to fit a raised surface or ways within the stock—and a stock of this kind requires two set-screws, one on either side, as it is impossible to mill for these ways up to a square corner.



Gang-mills. (Pratt & Whitney Co.)

78. *Milling Tools or Cutters.*

All cutters having lips with a face or breadth of over three fourths of an inch should be cut so as to leave the front or cutting edge of the lips somewhat hooked. This means if you draw a line across or through the centre on one end of a cutter having a diameter of six inches the cutting-edge will stand a sixteenth of an inch in front of said line. This will give the cutter a shaving cut instead of scraping the metal or chips from the piece of iron or steel



Stem Cutter.

that you design for use, and this principle is the same as in turning a shaft with a diamond-point tool. You would not think of setting the point of such a tool down as low as the centres in your lathe. This principle, however, would not answer with thin cutters, for if the lips of such were cut to stand in front of this centre line the lips would get caught and be torn out, unless you were very careful when starting a cut. All cutters of one fourth of an inch in thickness or less should have a series of small holes drilled through them near their

holes. This would to a certain extent prevent them from warping or becoming dished in shape when hardening. For this reason, the outer periphery being so much greater than that around the hole, the shrink would be accordingly so much greater, and by having the small holes through them their edges would become much harder than a plain surface. In drawing the temper of any but very thin cutters they should be drawn to a very



Spiral Mill.

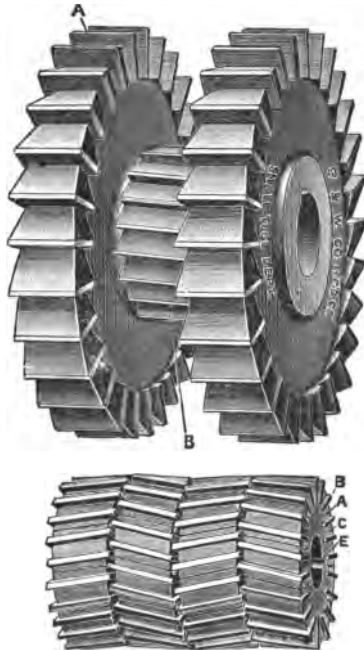


An Angular Cutter.

light straw-color, and very broad cutters require no drawing. Cutters having very coarse lips should be cut so as to have the bottom of each cut rounding in shape ; this leaves them much easier to clean. In large cutters the size of the round may be three sixteenths of an inch wide, and cutters with lips made in this way require less time in milling out than those having the lips cut sharp at the bottom of each lip, as you get the required space between them without the depth.

79. *Proportionate Numbers of Lips in Different Sizes of Cutters.*

All cutters having the face or breadth of their



Gang-mills. (Pratt & Whitney Co.)

lips over three fourths of an inch should be cut in a spiral form, and should have the holes through

them one five hundredth of an inch below the size required when finished, and those having a breadth of seven eighths of an inch and above should have their holes chambered a thirty-second of an inch above their sizes required to within three sixteenths of an inch from their ends. This is done to save time in grinding their holes to the size required after they have been hardened. The proportionate number of lips to each size is described in the following tables herein enumerated :

Cutters 6 inches in diameter should have 30 lips.

Cutters 5 inches in diameter, 35 lips.

Cutters 4 inches diameter, 40 lips.

Cutters 3 inches diameter, 45 lips.

Cutters 2 inches diameter, 50 lips.

These sizes are for cutters having a breadth of lips one inch and above.

Cutters $1\frac{1}{2}$ inches diameter and $\frac{3}{4}$ of an inch breadth, 38 lips.

Cutters 1 inch diameter by $\frac{5}{8}$ breadth, 25 lips.

Cutters $\frac{3}{4}$ of an inch diameter, $\frac{1}{2}$ of an inch thick, 20 lips.

Cutters $\frac{5}{8}$ diameter, $\frac{1}{2} \times \frac{3}{8} \times \frac{1}{4}$ thick, 15 lips.

Cutters 4 in diameter $\times \frac{1}{4}$ thick, 45 lips.

Cutters 4 in diameter $\times \frac{3}{16}$ thick, 45 lips.

Cutters 4 in diameter $\times \frac{1}{8}$ thick, 45 lips.

Cutters 4 in diameter $\times$ $\frac{3}{32}$ thick, 70 lips.

Cutters 4 in diameter $\times$ $\frac{1}{16}$ thick, 85 lips.

Cutters 3 in diameter $\times$ $\frac{1}{4}$ thick, 45 lips.

Cutters 3 in diameter $\times$ $\frac{3}{16}$ thick, 45 lips.

Cutters 3 in diameter $\times$ $\frac{1}{8}$ thick, 50 lips.

Cutters 3 in diameter $\times$ $\frac{3}{32}$ thick, 85 lips.



Hollow Mill and Collar.

Cutters 3 in diameter $\times$ $\frac{1}{16}$ thick, 110 lips.

Cutters 2 in diameter $\times$ $\frac{1}{4}$ thick, 50 lips.

Cutters 2 in diameter $\times$ $\frac{3}{16}$ thick, 60 lips.

Cutters 2 in diameter $\times$ $\frac{1}{8}$ thick, 60 lips.

Cutters 2 in diameter $\times$ $\frac{3}{32}$ thick, 70 lips.

Cutters 2 in diameter $\times$ $\frac{1}{16}$ thick, 85 lips.

Cutters $\frac{1}{12}$ in diameter $\times$ $\frac{1}{4}$ thick, 30 lips.

Cutters $\frac{1}{12}$ in diameter $\times$ $\frac{3}{16}$ thick, 30 lips.

Cutters $\frac{1}{12}$ in diameter $\times$ $\frac{1}{8}$ thick, 32 lips.

Cutters $\frac{1}{12}$ in diameter $\times$ $\frac{3}{32}$ thick, 42 lips.

Cutters $\frac{1}{12}$ in diameter $\times$ $\frac{1}{16}$ thick, 44 lips.

Cutters 1 in diameter $\times$ $\frac{1}{4}$ thick, 20 lips.

Cutters 1 in diameter $\times$ $3/16$ thick, 20 lips.

Cutters 1 in diameter $\times$ $1/8$ thick, 20 lips.

Cutters 1 in diameter $\times$ $3/32$ thick, 22 lips.

Cutters 1 in diameter $\times$ $1/16$ thick, 28 lips.

80. *Proportions of Broad Cutters.*

Cutters half an inch in diameter should be cut thirty to the inch, and contain fifteen teeth of one sixteenth of an inch deep.

Cutters three fourths of an inch in diameter should be cut thirty-two to the inch, and contain twenty teeth of one fifteenth of an inch deep.

Cutters one inch in diameter should be cut twenty-eight to the inch, and contain twenty-eight teeth, of one fourteenth of an inch deep.

Cutters one and a half inches in diameter should be cut twenty-four teeth to the inch, and contain thirty side teeth, one twelfth of an inch deep.

Cutters two inches in diameter should be cut twenty teeth to the inch, and contain forty teeth, cut one tenth of an inch deep.

Cutters three inches in diameter should be sixteen to the inch, and contain forty-eight teeth, cut one eighth of an inch deep.

Cutters four inches in diameter should be thirteen to the inch, and contain fifty-two teeth, cut one sixth of an inch deep.

Cutters five inches in diameter should be cut, eleven to the inch, and contain fifty-five teeth, cut one fifth of an inch deep.

Cutters six inches in diameter should be cut ten to the inch, and contain sixty teeth, cut one fourth of an inch deep. The teeth of these cutters should always be cut hooking, and the large sizes should be left nearly a sixteenth of an inch thick at the edge. The outer surface of the cutter should be draw-filed nearly square with the faces, as they cut more smoothly than when filed too sharp. Harden and draw not, except for thin cutters.

81. *Punches and Dies.*

In making these tools first plane two sides and the edges of a block of steel from which a die is to be made in such a shape as to have it enter the jaws where it is to be held ; this shoe when in use is bolted to the bed-plate on a punching-machine and is secured in any desired position. Now you will make the die on its upper side as smooth as possible with filing and cover it with a coat of sulphate of copper ; then if the die is to be made from a drawing first make a template from thin steel the exact size and shape shown on the drawing. Next place the template on the block so as to have the centre of the hole in the template come as near the

centre of the block as possible and clamp the template to the die, then with a sharp point mark through the template distinctly the outlines of the hole cut through the template; then with a drill of about three sixteenths of an inch in diameter drill the holes inside the lines and as near together as possible; then with a counterbore enlarge every second hole an eighth of an inch to within one third of an inch from the upper side; then with a broach about a tenth of an inch thick and made tapering on the edges split the holes one into the other until the piece inside will drop out. Now with a small stem-cutter mill out the lower side to the sides and depth they were made with the counterbore; then if the die is large enough mill the upper side out nearly to the lines you have marked. It will then be finished by filing to the lines, and the inside should be tapering so as to have the lower inside of the upper or cutting part about a hundredth of an inch larger than the edge at the upper surface. To save time in grinding the face of a die after it has become dull the upper side should be planed one fourth of an inch on its outsides lower than the cutting part and up to within three eighths of an inch from the cutting-edges. In making very long or large dies for punching heavy metal they should be made shearing; that

means they should be made at their opposite ends or extremities about an eighth of an inch lower than at midway on their cutting surface, in order to prevent whole pressure of the punch from coming upon the whole surface of the die at once, and thereby release the strain on the machine that does the work of punching.

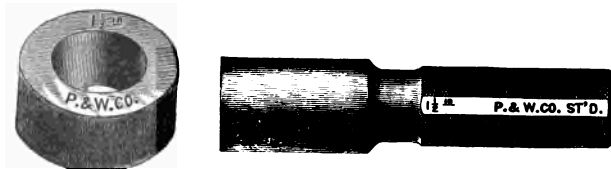
82. *Next to make the Punch.*

And to do this first square the ends of the piece you are to make it from, and have the lower end filed very smooth; and fit the upper end into the slide or socket that is to secure it; then on its lower end put a coat of sulphate of copper or blue vitriol: this is done to have the marks to be made on the end show more plainly than they would if the end were left bright. Now place the die in a vise with its centre to correspond with the centre of the punch, and if you have room for a clamp fasten it into its proper position, and with a sharp point mark through the die on the end of the punch the desired outlines. Now place the shank or upper end of the punch within the jaws of a chuck, with an index attached to it if you have one, or if not a vise will answer, and with a small cutter mill down to the lines made on the end as near as you can, and longitudinally about half an inch from the end—

except, however, that if it is a small or a thin punch, then finish with files or with hard chisels, and by whittling near enough to the lines aforesaid so that the punch can be forced through the die. Next place the punch within the slide or socket that is to hold it and force it through the die, and in doing this oil both the punch and die; then withdraw or drive the punch from the die and ease it up with a fine file until it will enter the die freely, then harden and draw it to a straw-color. Some punches have the shank or part that enters the slide or socket made tapering; in such a case the shank should not be fitted until the milling is done, as it would be difficult to hold it either in a chuck or in a vise.

83. *Making Gauges.*

Gauges to measure the inside of a hole are called cylindrical or plug gauges, and for large holes they



Cylindrical or Plug Gauges, Male and Female.

should be about five inches long, and have a body or the part to be used in measuring three and a half

inches long, and should have a head turned and milled on the opposite end ; this end is held by the hand while measuring. The body should be turned a sixty-fourth of an inch above size, then hardened without drawing the temper, and then ground to the



Knurling Mills and Stock, showing work. (Pratt & Whitney Co.)

size desired. Then to make the female, or part for measuring the size of a shaft or a stud, it should be two and a half inches long, and should then have a hole bored through it about a hundredth of an inch below the size required when finished. Then to prevent it from springing it should be case-hardened

and the temper not drawn ; then with lead cast upon arbors of square steel the holes are ground to size with oil and emery around the outside of this lead, and great care must be taken in this grinding, as the outer ends of the hole will be the first to come to size. The lead should be not over an inch long in order to grind the holes evenly or to the same size inside as they are at the ends of them. The arbors are of course run in a lathe and the gauge is held with clamps ; for small holes some of these gauges need not be over an inch in breadth, and then vary according to the size of the hole.

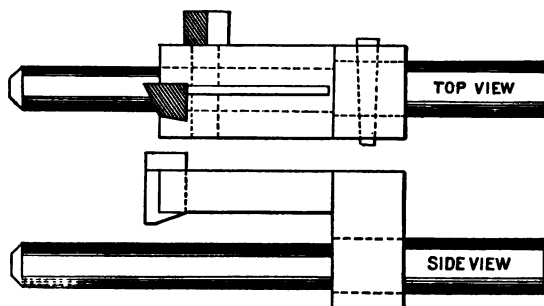
Snap gauges or those having slots cut in the edges may be either round in shape or oblong, and should be about three eighths of an inch in thickness. Those made oblong should have one end shaped for a handle and about three and a half inches long, according to the size, and with a body of any length desired. These gauges are also used to get the size of shafting, screws, etc., and of metal of various shapes. Those used to get the size of shafting screws or wire should have the slots cut once and one half in depth of the size of the shaft or any round object to be measured ; they should first have a hole drilled at the bottom of each slot about a sixteenth of an inch larger than the slot, or larger still, according to the size of the slot. They should

then be milled and filed to about three hundredths of an inch below the size desired when finished, then case-hardened, and with a thin copper wheel with emery and oil ground to the size required. This class of work mentioned above is now usually measured with a micrometer, excepting, however, when an immense number of pieces of one size are to be measured. In grinding these slots the gauge should be placed on a rest set exactly parallel to the arbor, and the rest should be at an exact distance from the arbor at either of its ends. Gauges for pieces of various shapes where great accuracy is required should be made as near as possible to the desired shape and about a thousandth below size, and then case-hardened and ground by the hand with pieces of copper, emery, and oil.

84. *A Tool for Turning the Outside of a Box.*

This tool is designed for doing the work usually done with a hollow mill, and contains a cutter that can be adjusted to turn instead of milling the outside of a round box or bearing on a machine. It is simply an arm driven on to an arbor, and is secured by a pin that passes through it; this arm is made angular in shape, and its outer portion hangs over one side of the arbor, and the side next the arbor in large-sized ones is about five eighths of an inch

from the arbor; at the end of this portion of it a cutter is inserted and is held by a screw that passes through the arm in the rear of the cutter, and the arm is slotted so as to form a clamp for holding the cutter. This portion of the angular piece that holds the cutter must be somewhat longer from the part



A Tool for Turning the outside of Boxes.

that crosses, and is secured to the arbor to the face of the cutter, than the box that is to be turned with it. The end of the arbor in front of the cutter should extend about one and one half inches, and this end of the arbor is turned to fit the hole in the box that is to be turned. This tool is an invention of the author, who has applied for a patent on it.

85. *Jigs for Drilling.*

In making these jigs from drawings where numerous holes are to be drilled of various sizes it is

well to make a template of sheet steel about a tenth of an inch in thickness. This plate should be large enough to extend about three fourths of an inch outside of the holes that are at the greatest distance apart, and one edge of this plate should be made exactly straight; next, one end of this plate should be made square with the edge you have straightened: and these two edges of the plate are the guides to measure the holes from. Now lay the drawing on a smooth surface, and lay the plate on the drawing and adjust it to have these two edges three fourths of an inch from the outward holes; then with a pencil having a sharp end mark a very light line on the drawing next the two edges of the template already straight and square. Now with a square set on one of these outside lines on the drawing draw with a pencil across the centre of each hole a line and extend to the line where your square rests. Next move the square to the other line and mark at a right angle across the centre of each hole, and extend the line as before to the line where the square rests. These lines running from the holes to the outside lines are to get the distance when transferring the holes on the drawing to the template; and now to transfer the holes on the drawing to the template you will place the beam of a square against one edge of the tem-

U. S. A.

plate, and from the other edge of the template that is parallel with the blade of the square measure from centre of each hole on the drawing to the line drawn on its outside (with dividers); then place the blade of the square on the template the same distance from the edge as shown on the drawing, and scratch a line at the edge of the blade. Next set the beam of the square against the edge you have measured from, and scratch a line across the one you have made at the distance from the centre of each hole, as shown on the drawing, to the edge of the template. It is well, however, in order to avoid mistakes and also to get the holes in an exact position, to scratch a line across four sides of each hole, and then with sharp dividers to strike a quarter circle the same size as shown on the drawing to meet the lines made at right angles. Next with a centre punch mark the centre of each hole deeply, then with drills a fortieth below size drill the holes; then place the template on the drawing and see if the holes in it correspond with those on the drawing; if they do not, file the holes until each hole is perfectly true with those on the drawing. Now clamp the template to the piece of casting or other metal that you design to make the jig from; but you must clamp the template to the under side of the jig, and in a position as to have

THE BOSTON MACHINIST.

the holes within it the same distance from the two working surfaces as the holes on the piece to be drilled are to be from its two edges or sides that are to rest against these two working-surfaces on the jig while the said holes are being drilled. These working-surfaces form a part of the jig, and are at one side and one end on its lower surface, and are raised an inch or more from it, and are planed square with the lower surface of the jig, and act as a support for one side and one end of a piece while the holes are being drilled ; and opposite these working surfaces and near one end and one side of the jig studs are set, with set-screws through them that screw the piece to be drilled against the said working surfaces. Now clamp the two squared edges of the template against the two working surfaces on the under side of the jig and scratch the holes on the jig through the template and drill them about a twentieth of an inch below size, and then redrill the holes with drills the size of the holes in the template, using it as a guide for the drills ; but the template should be removed before using the first drill, and replaced with its outer edges on the outside surfaces while enlarging the holes to their full size. After drilling the holes counterbore them three sixteenths above this size and fit the bushings, leaving a portion of each ex-

tend above the upper surface of the jig about one fourth of an inch, and the diameter an eighth of an inch above the size of the hole after it is counter-bored ; then with a hand tool round and polish the outside end of each hole, then harden and drive the bushings to their places. In making jigs for drilling small pieces, the holes in one a sample having the holes drilled in a proper position, you may drill these holes through it and then use it to drill the holes in the jig from, and in doing this place the face of this sample or side you have drilled it through from next to and on the under side of the jig, and secure it against the two working surfaces by the set-screws, and then drill the holes in the jig through from the under side ; then counterbore the holes from the upper side, and make the bushings as shown above, and set them in their places.

86. *A Few Words as to Master Mechanics.*

It may safely be said that not one master mechanic in twenty knows his business thoroughly. Nineteen of that twenty will only buy such heavy tools as he is forced to have in order to do his business, and then, for the want of a few small tools, that would cost comparatively nothing, some cotton waste with which to keep them clean, and a

little care to see that it is done, his shop will be encumbered with rubbish and filth, his lathes, planers, milling-machine, etc., etc., covered with grease so as to be unfit for use, and his men spend one third of their time looking for a bolt, strap of iron, or some other petty thing, of less worth than the time spent in looking after them. These are the shops that generally go to ruin. And all this for the want of a superintendent who has common-sense, and is not asleep on duty. These remarks, however, do not apply to shops where guns are manufactured, as it is well known that they are kept in order. The mechanic who knows his business thoroughly will have every tool kept clean and in its place. He will have a sufficient number of taps, lathes, reamers, drill- and planer-tools, with all other small tools, so that no man need wait a moment for want of them ; for "time is money." He will keep his dogs, gears, cutters, and drills as near the machines they are used upon as possible, and thereby save trouble, and be more likely to insure them in their places. He should have for every planer half a dozen straps, made of one-inch by half-an-inch iron, and bent in a U shape, near enough together to hold a three-fourths-inch bolt. These straps need no drilling for the bolt, and are far more "handy" than straps with holes drilled

through them. He should have three-fourths-inch bolts of a dozen sizes, with nuts an inch thick, in order to prevent stupid workmen from stripping them. He should see that the centres of arbors, when made, are countersunk, with a sink made to fit a triangular gauge, and that the centres of the lathes likewise are kept perfectly three-square. Unless he does this the arbors will spoil the centres of the lathes, and the centres of the arbors will soon wear out of true, and the arbors thus be rendered worthless. He should have plenty of drills, so they need not be altered every time he has a new hole to drill. He should have holes for drills in all small collets, of such a size that one drill can be used in any part of the shop ; and the large ones likewise.

87. *Lessons to Amateur Inventors and Others Who Propose to Become Inventors.*

Amateur inventors should know that seventy-five per cent of all patents issued from the Patent Office are not worth the cost of obtaining them. The reason for this is as soon as a young inventor gets an idea that he has something new he immediately has an application made and sent to the office for a patent, without looking through the stores, shops, or factories where such machines,

implements, or material may be seen, which, if he should do, he would find something like it and often far better than his, and this would show him that his was of little or no commercial value. In the course of thirty years' experience as an inventor this has occurred to me over twenty times. Therefore I would say to amateur inventors, When you get an idea that you think is new on a machine, or for an improvement thereon, or an implement or a material or other article, or a compound, before you apply for a patent look carefully through such stores as your improvement is likely to be found at, and also through such shops or factories as you can gain an admittance within. Then you will have found whether there is not on the market or in use something alike or perhaps better than yours. And if you find nothing better or alike it, then it is usually safe to apply for a patent; and when you do this be careful that you employ an honest solicitor and one who knows his business thoroughly, as not one in ten of the solicitors of patents are competent to draw a complicated case properly. And no man or solicitor is competent to draw up a case in a complicated case unless he is well up in the principle of general mechanics and the various mechanical movements and devices that pertain to forming a machine. Several years ago I

gave a case to a solicitor who is also a patent lawyer who toyed with it and also with me for weeks, and finally told me he was not mechanic enough to draw the specification and claims for so complicated a machine, but wished me to draw them for him to copy. I then drew them up and gave the case to another solicitor. Boston, like all other cities, contains too many impostors who get an inventor's money for obtaining a patent that when issued is almost worthless, and merely because he has employed a fool for his solicitor. And for the benefit of inventors I recommend the firm of Crosby & Gregory, whose office is at No. 34 School Street, Boston, who during the past thirty-five years have acted as solicitors for me in some twenty cases, and from their long experience and thorough knowledge may be considered the most reliable, and as expert as any, in their very scientific and difficult profession. Several times have I taken them something that I thought was new and of great value only to be informed they could only get very small claims on it, and there was no money in it, for the reason that it was nearly covered by a previous patent. As to their charges, they are the most liberal.

When an inventor has his papers drawn and entered into the Patent Office, it is well to make a

small machine, mainly of wood ; then he will see if there is any necessary changes to be made in the construction of it, and it costs not one fifth the price to make one of wood that it does to make one of iron. This, however, is not always practicable, especially in a complicated machine ; but when it can only be made of metal it is only necessary to have the various working parts well fitted, and no fine finishing is needed, for the reason that a first machine rarely comes up to the promised expectations, and in such a case all the work done in finishing a first machine is thrown away.

After one machine is made to suit your ideas it should be put into use and thoroughly tried in order to see if there is any fault to be remedied before building any large quantity, as I have seen millions of capital wasted in building machines before the parties had a good machine to build from.

Beware of lawyers. About one third of them are as useless as the work they pretend to do for you, and think more about your money than your work ; and when you employ one be sure you have one that knows his business, and will not lie, cheat, and steal. They are, of course, all honorable men.

Again, after an inventor has received his patent papers he should, unless he has plenty of capital to make and place the product of his invention on

the market, he should find a capitalist to make and sell the machine or material covered by his patent, and have the manufacturer and seller thereof pay him a royalty on every machine or other product of his invention sold; and he should be sure and not be caught by one who pretends to have money,—as there are thousands of these,—and who at the same time have not a dollar that they can call their own. Every large city has too many of this class of people. The inventor should also be careful and not be caught by a certain class of men known as promoters; many of these people will tell you they can control others who are their friends and have millions to invest in any enterprise. These men never invest a dollar themselves; indeed, three fourths of them have none to invest. They will propose to form a company composed of their friends to manufacture and sell your property and pay you in the stock of this company for your patent; you assign it to the company that has not ten dollars in the treasury to begin manufacturing; then their bogus company bursts, and you have lost your patent by assigning it to them. Therefore, when you assign your patent to a company, be sure you have solid men in it who have the means to manufacture it within a certain limited time, and have the assignment read that in the event of their

not manufacturing your machine or material within that specified period the patent shall then belong to you, and that you shall then have the full and exclusive right to either sell it or manufacture and sell any property covered by the claims in your patent. Do not depend on a reassignment, for this they may not do. Again, the inventor should be on the alert for parties who, for a small consideration, try to have him assign to them a limited portion of his patent; for this reason, that as soon as a man or a company has merely one tenth of a patent assigned to them it gives them as full a right to manufacture and sell as if they owned the whole patent, and they are not accountable to the inventor for one penny. The assignment of a certain portion of a patent does not, however, grant the party who obtains it an exclusive right to manufacture and sell the material covered by such patent, but the inventor can either manufacture and sell or he may sell the remaining portion of said patent whenever he desires. And again, when an inventor gives a license to any party to make and sell the property covered by his patent on a royalty, he should demand a certain sum in advance as a guarantee that the party to whom he grants a license shall fulfil all the provisions of his license, and that the sum advanced shall be forfeited if the party

who has obtained said license does not build a certain number of machines or other material covered by his patent within a specified period of time ; otherwise a party may obtain a license to manufacture and never build a machine or any material covered by his patent. This has been frequently done by parties of wealth, and who were supposed to be honest men, but who in fact were far worse than thieves, for thieves run a risk of going to State prison, and Boston has plenty of such parties. This the writer happens to know by experience.

88. *A Form for a License.*

Whereas I, John Smith, of Norwood, in the county of Norfolk and in the State of Massachusetts, have obtained letters patent of the United States for sewing-machines, the same being numbered as 396,745. And whereas Silas Philips, of Salem, Mass., is desirous of gaining an exclusive license to manufacture and sell the aforesaid machines. Now this indenture witnesseth that for and in consideration of one dollar to me in hand paid by said Silas Philips and certain other valuable considerations I, John Smith, do hereby grant the said Philips a full and exclusive license to make and sell the aforesaid machines in all of the United States ; and this license further provides that the said Philips shall

pay quarterly the sum of twenty dollars as a royalty on each and every machine sold, and that every machine shall be numbered, and that the said Philips shall make and place on the market at least six machines within five months from the date upon which this license was granted; and it is further agreed that the said Philips shall advance to the said Smith the sum of three hundred dollars, this sum to be held as a guarantee for the faithful performance of all provisions of this license, and that in case any of the provisions of this license are evaded and not carried out this license shall be forfeited and become null and void and of no further use. And the three hundred dollars advanced by said Philips shall also be forfeited for non-fulfilment of the provisions of this license. To which we hereby place our signatures and names, this fifth day of March, 1896.

JOHN SMITH,
SILAS PHILIPS.

HENRY C. LODGE,
HENRY C. GREENHALGE,
Witnesses.

89. *Inventors and Mechanics Contrasted.*

Many people think that an inventor is only a highly educated mechanic, and that any good me-

chanic must also be an inventor. In this they are greatly mistaken, as there are numerous inventors who know very little about mechanism, and nearly all inventors who have made any great success were born inventors, or, like the poet, he is born and not made, and all the education he may gain will make him, the poet, merely a verse-writer. There are many others who class all men who have learned their trades as mechanics, and as such in every sense, when in fact nine tenths of them are merely workmen who are foiled every hour unless they have a master mechanic to instruct them about their work, especially when they have to work from drawings; and any man to be a great mechanic must be one of superior intelligence and some original ideas for designing and applying the general elements that are contained in the many different kinds of constructed machinery, and making drawings therefor, and know all about the shrinkage of the various kinds of metals, and also when patterns are made properly.

90. *Making Drawings, etc.*

In making drawings for a complicated machine it is well, in order to have the workman understand the numerous parts without becoming confused with the lines, to shade the main parts with

colors of different shades; this can be done, with but a small loss of time, with wax pencils. And in making drawings for patterns from which iron castings are to be made, an eighth of an inch to a foot is allowed for shrinkage: that is, if a piece of casting is wanted two feet long, the pattern must be two feet and one fourth of an inch long; and in making patterns from which brass or composition castings are to be made, three sixteenths of an inch to a foot is allowed for shrinkage. And if the edges or outside of a casting is to be raised, its height and shape should be shown in an end view on the drawing. In drawings for boxes to be lined with Babbitt metal the guard at each end for holding it should be shown a sixteenth of an inch below size, —for this reason, that in casting boxes the guards seldom come true with the outside, and in such a case the side coming nearest the centre can be filed until they measure the same from the outside as the opposite side; then a rose reamer should be run through the guards of the same size as the shaft that is to revolve within it. In boxes that are cast to the frame of a machine only the outside guard should be cast below size, and this guard should be treated in the same way as shown above, while the inside guard may be cast a tenth of an inch above the size of the shaft, and all boxes

where the machine is not too heavy should have the lining metal poured from one end, as it insures a more solid lining than when poured from one side ; but where the box is in two halves this cannot be done, as only one half can be cast at one time : then when casting them, first fill the one cast on the machine, then place a piece or strip of paper over the outside edge of the lining next the shaft, then screw the outside half of the box to its place, and fill it. In lining boxes the shaft or arbor used should be heated hot enough to melt the metal, as the metal will cool as soon as it is poured and the shaft will then come out easily, and will also insure a solid lining, which would not be the case if the metal was poured against a cold shaft ; and before filling a solid box place a collar or place putty around the shaft at the end or ends of the box or boxes.

91. *A Few Words to Men of Capital.*

Parties about to start a factory and manufacture machinery should first find a man of brains and large experience in the kind of machines they propose to build, and it is well to have one with some education for superintendent. I have often observed advertisements for a graduate of some institute of technology to superintend a machine fac-

tory, and have seen several of these men who were of no use and entirely failed, merely for want of practical experience: they only know what has been driven into them at an institute. Some years ago a certain company started in Boston a shop for the manufacture of rifles, and employed a petty lawyer to superintend it who never had any practical experience; the result was he nearly ruined the concern, as he had one previously. Then they had their eyes opened, for he had spent nearly a million dollars for tools that had to be thrown away as useless, and he was discharged, and a practical gun-maker was employed, with toolmakers who knew their business, and the company finally made some three millions in their enterprise. Again, a certain party whose father had died leaving \$300,000, entered the business of manufacturing shoe machinery. This man knew merely enough to employ his bookkeeper to buy tools for his factory that he knew nothing about, and were consigned to the storeroom as useless. The proprietor of this factory sunk all of his property within five years, and died a ruined and broken-down man.

Still another man who thought himself a great business man entered the business of manufacturing machinery, where he had over a dozen dif-

ferent kinds of machines to build, each of which required many special tools. This wiséacre would as soon as he got a superintendent to thoroughly master all of his machines and know all of the various tools for making them, discharge him, thinking his days of usefulness were over. Then he would employ another who knew little or nothing about his line of busines to go through a two or more years' experience before he became posted on the numerous machines and the special tools with which to build them. Next he discharged him, and employed a bookkeeper who knew nothing about machinery. The result was, he sunk nearly all of his \$75,000 that he put into it, and finally he became unable to raise sufficient funds to run his shop with only a half-dozen men, and it is said he burned his house to obtain the insurance. He also died a ruined and broken-down man.

This was not the way B. F. Sturtevant did his business, for he would only employ the best men he could find and paid them accordingly, and would also keep them as long as possible. His first question to a man applying for work was, Are you well up in this business? Then if he did not get an affirmative answer he would walk away and have no more to say with him. The author of this work happened to be his foreman for nearly four years,

and started his shop on Sudbury Street in Boston. He was then in debt nearly \$1200, and when the author of this left him to enter other business, he was making a profit of \$300 per week on his fan-blowers, peg-wood, etc. He died worth over a million dollars. My reason for leaving him was, I had invented a repeating or magazine rifle, that became the best in existence at that date—in 1864. Only a half dozen of them were made, however, for I had assigned one half of the patent to Harvey F. Payton & Co., who then occupied the best office on State Street. Payton then had the Honorable Wm. Sprague, of Providence, R. I., come to Boston, who had it thoroughly tried and sent to Springfield armory, where it was tried still further. Then Mr. Sprague offered to buy and pay \$50,000 for it, and then Payton began to play what he thought a sharp game and get all of the proceeds into his own and his partner's pockets ; but he played this game too long, or at least until Mr. Sprague became disgusted with him, and would have nothing to do with either him or his partner. Thus through his rascality he lost his \$25,000, and I mine. Soon after this our war came to an end and the rifle also, there being no use for it in America. Payton became so well known as a swindler that no man would do any business with him, and died a pauper. Another of